COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

December 1957

Mississippi Power Company's new Gulf Coast Plant

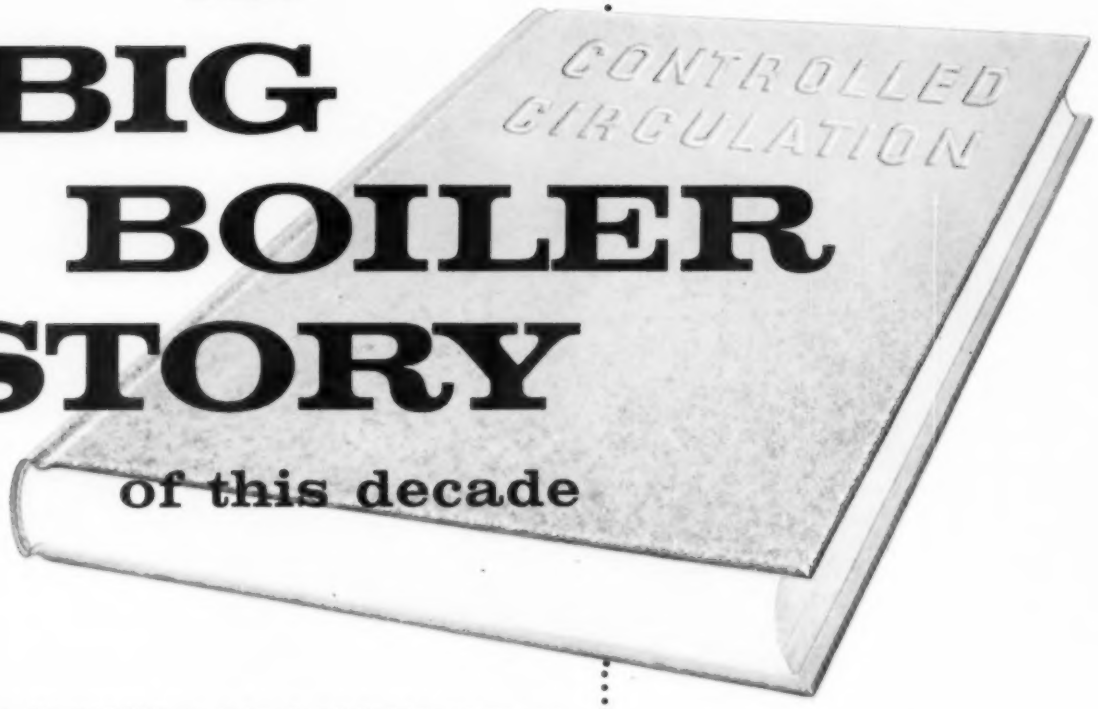
Hydraulic Couplings In Dual Role

Standardizing Insulating Techniques

Organizing Projects

ASME Annual Meeting—I

The BIG BOILER STORY of this decade



Along the great highway of American industrial progress, you will find milestones that mark the big forward steps – the major engineering and scientific developments that have inserted giant strides in the steady gait of progress.

Such a milestone is the C-E Controlled Circulation Boiler – the big boiler advance of this decade. How well this unique design of boiler qualifies as a milestone is revealed by the following facts of its acceptance since 1950 by leading utilities in this country and abroad.

Total order volume – $500,000,000

Total generating capacity – 20,000,000 kilowatts

This capacity, if used to serve only residential load, would supply the electrical needs of more than 130 million people. Unit capacities range from 75,000 to 500,000 kw. – the world's largest.

Preferred for high pressures – Today's trend in steam pressures is the 2400-lb range. More C-E Controlled Circulation Boilers have been purchased for this high pressure range than all other types combined.

Ever increasing acceptance – More and more utilities are adopting controlled circulation. The following companies recently placed their *first* orders, totaling 1,350,000 kw.

Central Illinois Public Service
Consolidated Edison Co. of New York
Florida Power & Light Co.
Pennsylvania Power & Light Co.

The C-E Controlled Circulation Boiler is a notable example of the results of Combustion's continuing program of research and development in all phases of steam generation. You can share in the economic benefits of this program by specifying "C-E" for your next boiler installation. Moreover, you can be sure of getting the right boiler for your needs since Combustion builds a type and size for every steam requirement.

REPEAT ORDERS

The utility companies listed below – representing 65 per cent of all purchasers of C-E Controlled Circulation Boilers – have averaged better than three contracts per company.

Boston Edison Company
Central Hudson Gas & Electric Company
Cincinnati Gas & Electric Company
Cleveland Electric Illuminating Company
Commonwealth Edison Company
Consumers Power Company
Detroit Edison Company
Duke Power Company
Houston Lighting & Power Company
Illinois Power Company
Kansai Electric Power Company
Kansas City Power & Light Company
Kansas Power & Light Company
Niagara Mohawk Power Corporation
Northern Indiana Public Service Company
Pennsylvania Electric Company
Philadelphia Electric Company
Potomac Electric Power Company
Rochester Gas & Electric Corporation
South Carolina Electric & Gas Company
Tennessee Valley Authority
Virginia Electric & Power Company
Wisconsin Electric Power Company

COMBUSTION ENGINEERING

Combustion Engineering Building • 200 Madison Avenue, New York 16, N. Y.

C-132

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

Vol. 29 **No. 6**

December 1957

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ROBERT D. TAFT
Business Manager

JOSEPH C. McCABE
Editor

GLENN R. FRYLING
Associate Editor

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BPA

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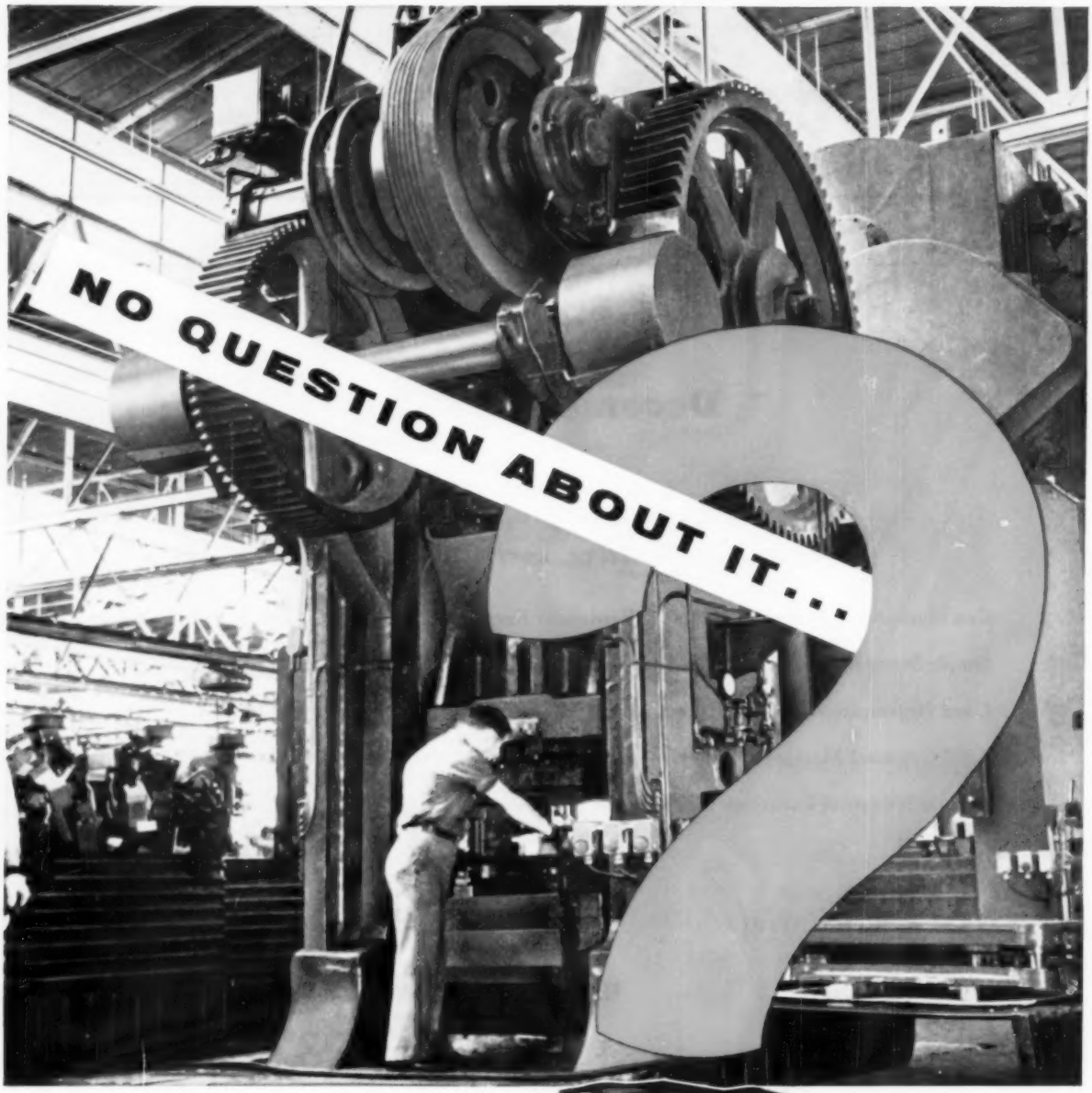


Bituminous is the dependable fuel for B&O *plant power*

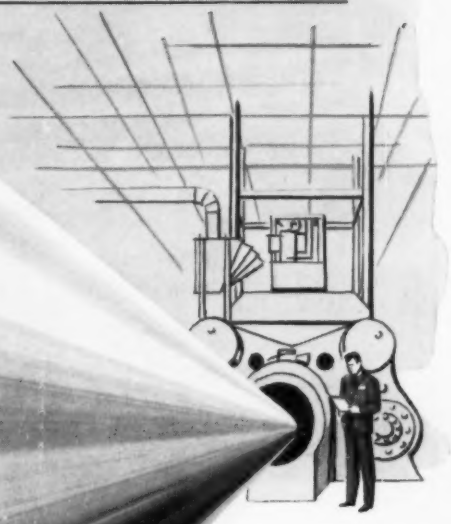
- Is it readily available?—*Yes, it's yours on order!*
- Is there enough for any future need?—*Sure thing, the supply is practically limitless!*
- How about present and future cost?—*Price is stabilized by expanding mine mechanization and increasing efficiency of modern burning equipment.*

B&O

BITUMINOUS COALS FOR EVERY PURPOSE

Ask our man! BALTIMORE & OHIO RAILROAD, BALTIMORE 1, MD., Phone: LExington 9-0400

FOR YEARS OF PIPE ECONOMY...



THIS EXTRUDED HEAVY WALL

PROTECTS

against severest heat, pressure and corrosion

Here is High Integrity pipe for the toughest applications in the power, petroleum, chemical and other industries. Extruded from any ferrous alloy in lengths up to 50 feet or more, and with virtually any wall thickness, this pipe from the Curtiss-Wright Metals Processing Division provides increased on-the-job life, long-term economy, elimination of down time – not just for months, but for years to come. Extruded to specification under tremendous one-push pressures from the Division's giant 12,000-ton horizontal steel extrusion press, Curtiss-Wright Heavy Wall Pipe is of uniform high strength and has high resistance to pressure, heat and corrosion. Write today for information on both your standard and special requirements.

87 GRIDER STREET

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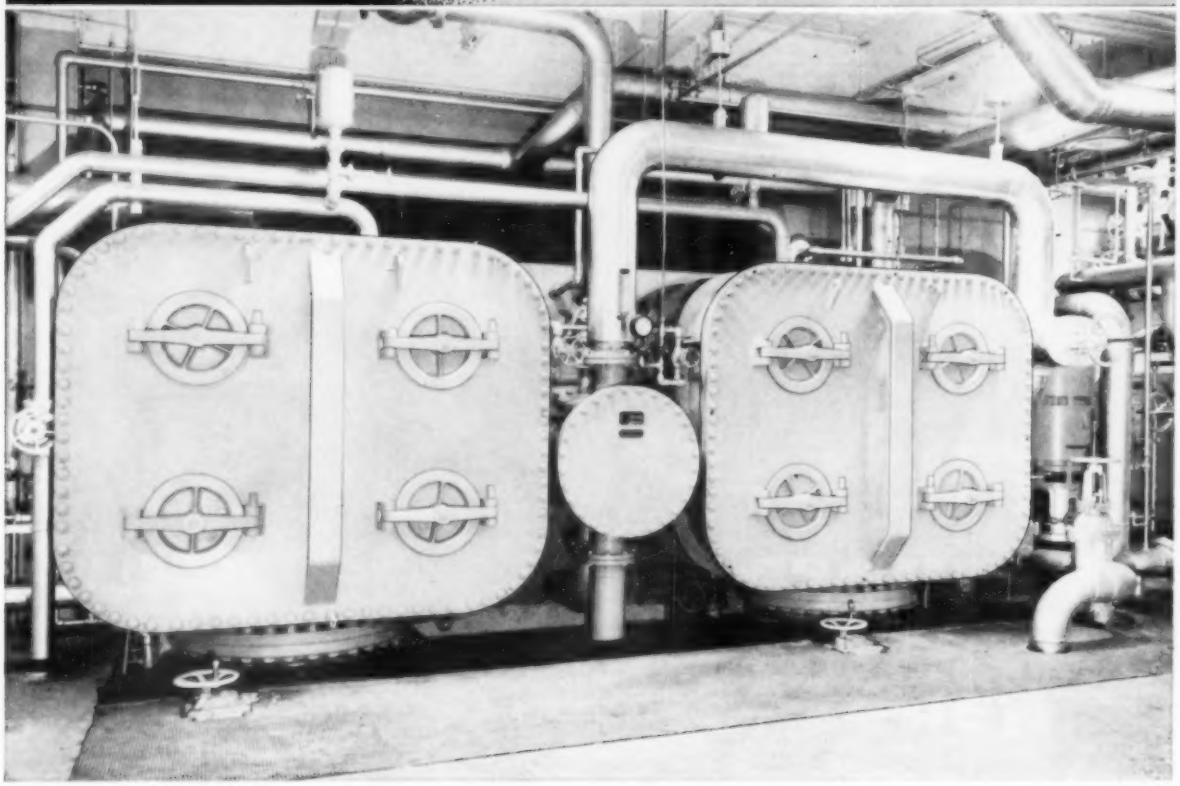
PROGRESS IN POWER through PROGRESS IN HEAT TRANSFER EQUIPMENT



NEW-DESIGN CONDENSERS SAVE SPACE AND MONEY

Steam generation of electricity has made tremendous progress in the last 25 years because of the ever-increasing efficiency of the equipment used.

A power equipment manufacturer with many "firsts" to its credit, Yuba is continually designing, among other equipment, condensers with low head room to save much-needed space. This advancement is illustrated above in the photograph of a rectangular shape condenser for the Suwanee River Plant of the Florida Power Corp.

A low pressure heater is installed between the tube banks to further save plant space, as well as initial cost for foundation and piping. An additional design feature of Yuba condensers is a de-aerating section within the condenser shell which eliminates the main plant de-aerating heater. Maintenance and downtime costs are reduced by welding tubes into tube sheets.

For advanced condenser design, that will save space and money, consult the Yuba Heat Transfer Division, formerly the Heat Exchanger Division of The Lummus Co.

YUBA

CONSOLIDATED INDUSTRIES, INC.

Other Divisions Manufacturing Heat Transfer Equipment
California Steel Products Division, Richmond, Cal.
Adsco Division, Buffalo, N. Y.

YUBA HEAT TRANSFER DIVISION
HONESDALE, PENNSYLVANIA
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REPRESENTATIVES IN PRINCIPAL CITIES

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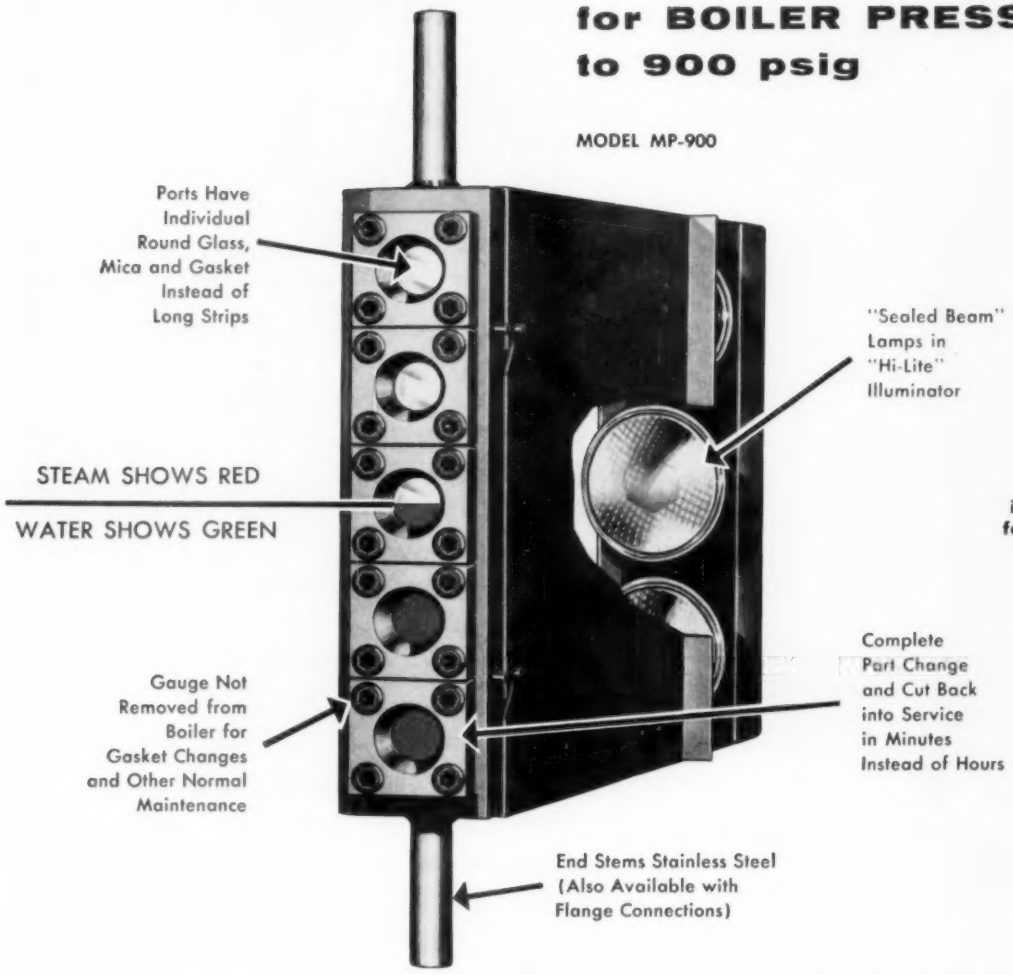
Sure-Reading ...DIAMOND "Multi-Port" Bi-Color Gauge

for BOILER PRESSURES to 900 psig

MODEL MP-900


Ports Have Individual Round Glass, Mica and Gasket Instead of Long Strips
"Sealed Beam" Lamps in "Hi-Lite" Illuminator
STEAM SHOWS RED
WATER SHOWS GREEN
Gauge Not Removed from Boiler for Gasket Changes and Other Normal Maintenance
Complete Part Change and Cut Back into Service in Minutes Instead of Hours
End Stems Stainless Steel (Also Available with Flange Connections)

Also available is Model MP-3000 for boiler pressures to 3000 psig

The individual round ports each having its own round glass, round mica and round gasket (instead of the conventional long strips) means less stress and strain . . . resulting in greatly reduced maintenance. When replacement is required, it is usually only one port . . . which can be changed in a very few minutes . . . and without removing the gauge from the boiler.

The Diamond Bi-Color feature is another important advantage of the MP-900 Multi-Port . . . steam always shows red and water always shows green. There can be no question of the water level.

Recommended for both new and old boilers up to 900 psig, the MP-900 Multi-Port will give you a new standard of gauge operation. Use the coupon below for additional information.

7757

DIAMOND POWER SPECIALTY CORP. V
LANCASTER, OHIO

Please send me without obligation a copy of new Bulletin No. 2044 explaining the advantages of the Diamond MP-900 "MULTI-PORT" Bi-Color Gauge for all boiler operating pressures up to 900 psig.

NAME_____

COMPANY_____

ADDRESS_____

DIAMOND POWER SPECIALTY CORP.

LANCASTER, OHIO

Diamond Specialty Limited • Windsor, Ontario

Cut the special-valve cost of high pressure service

with standard Edward High Pressure Valves!

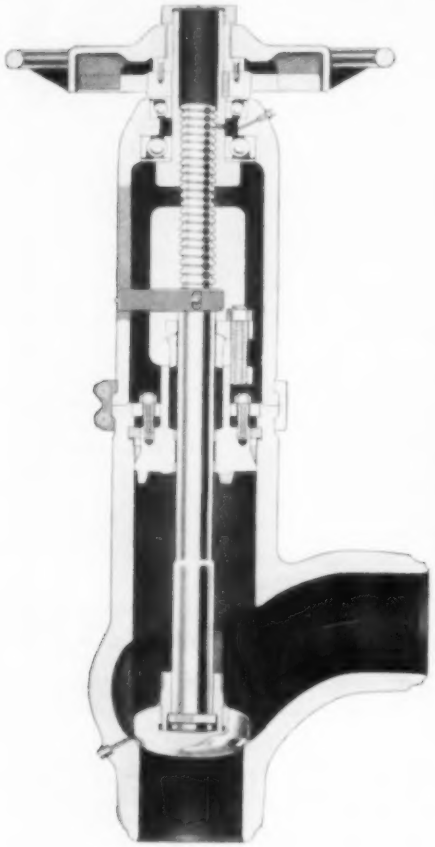


Fig. 7517

EDWARD UNIVALVES Ideal high pressure-temperature small valves for services up to 2500 lb at 1050 F, 6000 lb at 100 F.

High pressure and high cost *do not* necessarily go hand-in-hand as far as valves are concerned. Buyers all over the country have found that many features *standard* with Edward are expensive "*extras*" for other valve manufacturers. For example, *standard* Edward high pressure globe and angle stop valves in the larger sizes have these features *at no extra cost:*

- **EVALTHRUST BALL-BEARING YOKE** for easy operation
- **INTERNAL STREAMLINING** for minimum flow resistance
- **IMPACTOR HANDWHEEL** for tight shut-off under extreme pressure
- **GUIDED STELLITED DISK** eliminates vibration in throttling
- **INTEGRAL STELLITE SEAT** for wear-resistant sealing
- **IMPROVED EDWARD PRESSURE-SEAL** for leakproof bonnet joint
- **TIGHT BACKSEAT** for repacking under pressure

Room temperature ratings for standard Edward valves range up to 6000 lb; high temperature ratings go to 2500 lb at 1050 F. For corrosion resistance or for extremely high temperatures, appropriate materials can be supplied. For more details on high pressure Edward valves (as well as other Rockwell-Built Edward valves), write for the Edward Condensed Catalog.

Edward Valves, Inc.

Subsidiary of

ROCKWELL MANUFACTURING COMPANY

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EAST CHICAGO, INDIANA

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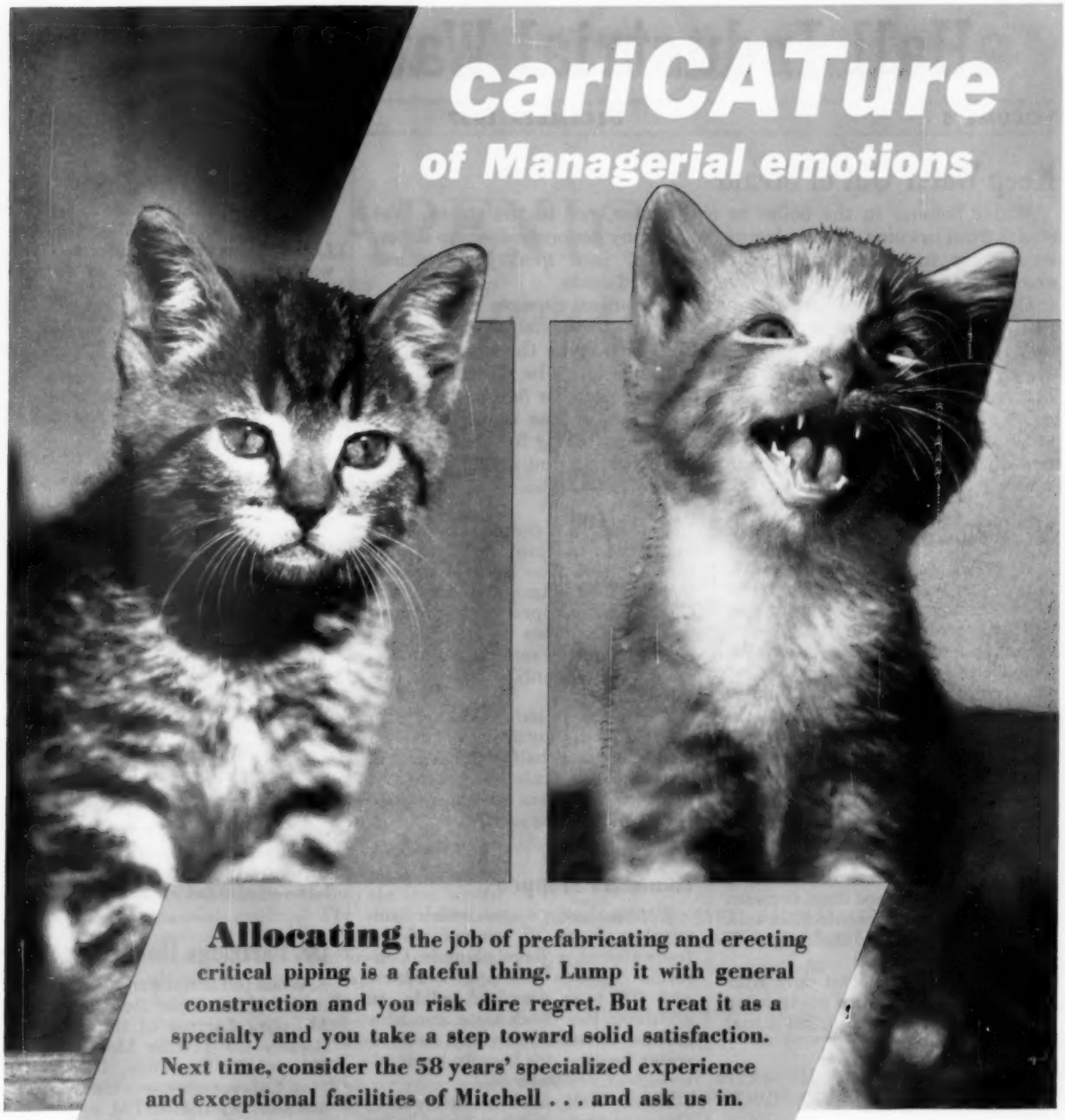
of Managerial emotions



Allocating the job of prefabricating and erecting critical piping is a fateful thing. Lump it with general construction and you risk dire regret. But treat it as a specialty and you take a step toward solid satisfaction. Next time, consider the 58 years' specialized experience and exceptional facilities of Mitchell . . . and ask us in.

W. K. MITCHELL & CO., INC.

Philadelphia 46, Pa.

WESTPORT JOINT
(PATENTED)

MITCHELL PIPING
SINCE 1899

PIPING FABRICATORS AND CONTRACTORS

Hall Industrial Water Report

VOLUME 5 DECEMBER 1957 NUMBER 6

Keep Water Out of Steam

Water belongs in the boiler or evaporator, not in the steam. Wet steam from priming or foaming of boilers may seriously damage superheaters or turbines. Evaporator vapor of poor quality introduces excessive amounts of solids to the boiler feed cycle.

Carryover problems can be solved. Mechanical changes may be the most economical answer. Perhaps the water level should be lowered, or its variation controlled more carefully, or maybe the baffles in the steam drum should be altered. But the problem may be a chemical one. Is there unsuspected contamination of condensate or feedwater? Or is the answer simple adjustment of blowdown or use of an effective antifoam? Hall engineers are experienced in searching for the best way to avoid wet steam. They stand ready to help you.

More Blowdown

A Georgia plant, plagued with gross carryover from a small HRT boiler, had tried unsuccessfully to solve the problem with a number of compounds offered as effective cures. Usually the compounds aggravated the condition. Finally, Hall Laboratories was called in to help.

Hall field engineer John Kenney quickly diagnosed the problem. Little attention was given to blowdown of the boiler, so the total solids in the boiler water frequently ran much too high. After Kenney gave the operators the proper test procedures to control boiler water conditions and trained them to maintain total solids concentration at a satisfactory level, the difficulty was completely eliminated.

Simple, wasn't it? But only after a Hall engineer applied his training and experience to finding the actual cause of the carryover.

Dye Bath Trouble

In spite of heavy blowdown, careful control of boiler water conditions and normal boiler steam loads, a New England finishing plant experienced serious difficulty in dyeing operations because of impure steam. Conductivity tests on samples of condensed steam from the bleach house showed continuous carryover with dissolved solids ranging from 14 to over 300 ppm.

There was little if any room for improvement in boiler water conditions. There was no detectable contamination of boiler feedwater that could easily be eliminated. There was no simple mechanical solution to the problem. Hall field engineer Bob Dow decided accordingly to feed Hagan C-1 Antifoam. Carryover stopped immediately. Conductivity tests on samples collected under the same conditions as before showed only a trace of dissolved solids.

Further work indicated that with the use of the antifoam, blowdown could be cut in half with savings in water and chemicals. Needless to say, plant management is happy with Hall Laboratories service.

Hammers Stopped

The makeup water which constitutes about 70 percent of the feedwater at a forge plant in California contains 325 ppm hardness and 800 ppm dissolved solids. In addition, the condensate available and the exhaust steam used for feedwater heating are heavily contaminated with cylinder oil.

When Hall field engineer Dick Carey tackled the job he found boiler water level fluctuating badly and so much water in the steam that the continual stopping of the forging hammers was seriously interfering with production.

The only change that could be made at once was the feeding of Hagan H.P. Antifoam. This turned out to be all that was necessary. The water level stopped fluctuating, carryover ceased and so did any difficulty at the hammers.

Water is your industry's most important raw material. Use it wisely.

Foaming Traced to Size

During a regular visit to a New York paper mill, Hall field engineer Lou Eppelsheimer was informed that water was foaming in a condensate pump and that a heavy deposit had built up on a turbine throttle valve in a week's time.

Subsequent analysis showed the condensate to have a high pH value and to contain raw water, considerable silica and much organic matter. The deposit on the turbine throttle contained boiler water salts, indicating carryover. A most significant clue was that the foaming condition occurred only on Mondays.

With this information as a guide the plant men and the Hall engineer were able to pinpoint the difficulty. In the plant, the size emulsion was prepared with raw water, a silica compound and glue. The hot mixture was transferred from one tank and atomized into others with a steam injector. When steam pressure dropped over weekends the emulsion was sucked back into the steam lines. As operations were resumed on Monday, the contamination was flushed through the traps into the condensate return system.

Suitably placed check valves and regular examination of condensate have eliminated all difficulty.

Dr. Partridge Honored

When industrial water was selected as the 1957 topic for the Annual Marburg Lecture of the American Society for Testing Materials, Dr. Everett P. Partridge, Director of Hall Laboratories, was chosen as the lecturer. At the ASTM meeting in June, Dr. Partridge showed where we stand as a nation with respect to what he called "Your Most Important Raw Material." Reprints of his lecture will be available.

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information write, wire or call Hall Laboratories, Division of Hagan Chemicals & Controls, Inc., Hagan Building, Pittsburgh 30, Pa.

Hall Laboratories—Consultants on Procurement, Treatment, Use and Disposal of Industrial Water

APEXIOR®
in today's power boilers

There's something basic about a power-field product with a job even more vital today than half a century ago — for technologically we've come a whole era since Apexior Number 1® first went to work inside boilers in 1906. The "why" of Apexior and its still-growing use in modern steam generators takes us, then, to fundamentals, best answered by asking—

WHAT IS APEXIOR?

Apexior Number 1® is a high-temperature, non-oxidizing, brush-applied coating for service on both heat-transfer and non-heat-transfer areas. Because it penetrates and becomes one with metal, Apexior seals surfaces at new, or newly cleaned, strength, isolating steel from its environment and establishing it as an independent element in steam generation.

WHY ARE BOILERS APEXIOR-COATED?

Maintaining the status quo to keep steel at peak efficiency is only the first benefit Apexior confers. The simple one-coat process actually transforms steaming surfaces. Because Apexior is smooth and deposit-repelling, metal stays cleaner longer — heat transfer is always at its highest — distribution is uniform — and circulation and evaporation proceed at top performance levels. Off the line, inspection is facilitated — cleaning, when required, is accomplished easily and quickly — and the boiler is soon back in better-than-ever steaming service.

WHERE IS APEXIOR IN USE TODAY?

Now manufactured in the United States and four foreign countries, Apexior serves the world around in electric utility central stations and plants generating power for every kind of manufacturing and service industry. Its first use half a century ago in Scotch marine boilers has been extended also over the years to floating power plants in vessels of every type and size.

CAN YOU APEXIOR-COAT ALL BOILERS?

Apexior serves under highest temperatures and pressures on any steam-or-water-contact area. It may therefore be applied to any water-tube boiler, including water walls, economizers, circulators, and reheat units — and to any fire-tube boiler where it serves on shell interiors and flue exteriors.

WHAT UNIT-SYSTEM AUXILIARIES ARE USUALLY APEXIOR-COATED?

- *Evaporators — interior surfaces, coil exteriors*
- *Deaerating heaters — shells and trays*
- *Feedwater heaters — interior surfaces*

WHAT PARTS OF STEAM TURBINES ARE APEXIOR-COATED?

- *Interior of casings and exterior of rotors, or wheels, and diaphragms.*

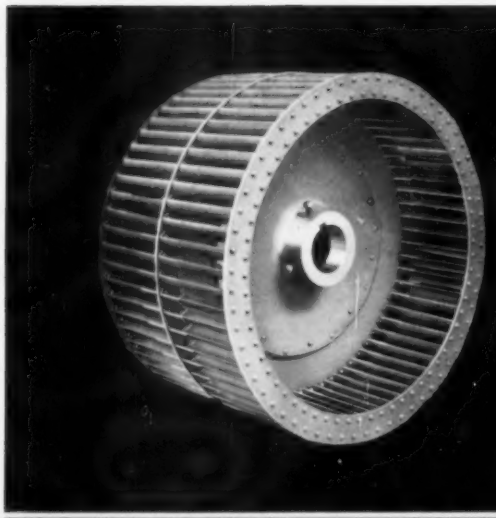
MAINTENANCE FOR METAL

This message is one of a continuing series. To be discussed: Apexior Number 1® in relation to . . . heat transfer, feedwater treatment, high-purity steam, standby, cleaning, cost. Watch for the answer to your question, or write

THE DAMPNEY COMPANY
HYDE PARK, BOSTON 36, MASSACHUSETTS

203

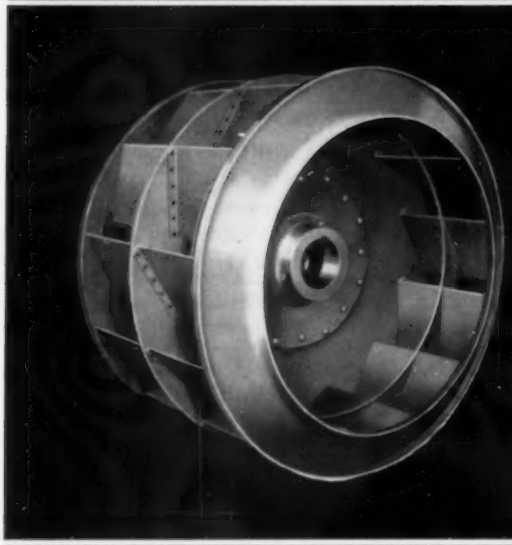
American Blower Fan Wheels



SIROCCO WHEELS

for forced and induced draft duty

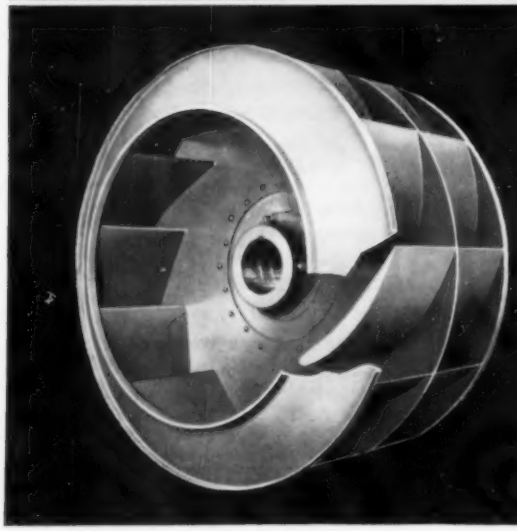
- For balanced draft or pressurized furnace
- Low tip speed
- Die-formed, forwardly inclined blades and heavy streamline inlets
- Used in power plants the world over



AHS WHEELS

for forced and induced draft duty

- Backwardly inclined, nonoverloading horsepower characteristic
- For given duty operates at higher R.P.M.
- Single thickness flat or curved blade
- Heavy rolled streamline inlets

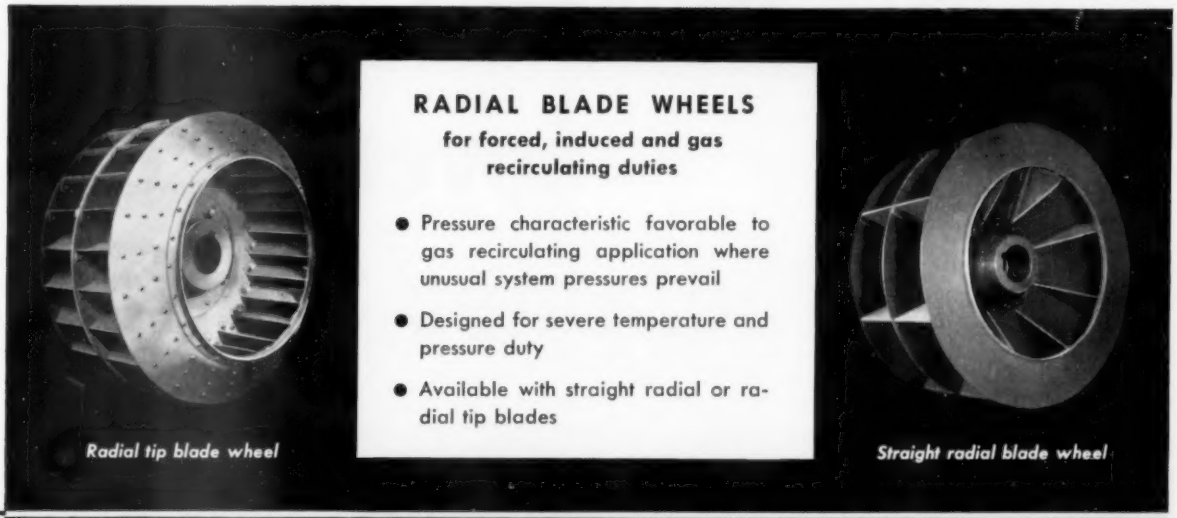


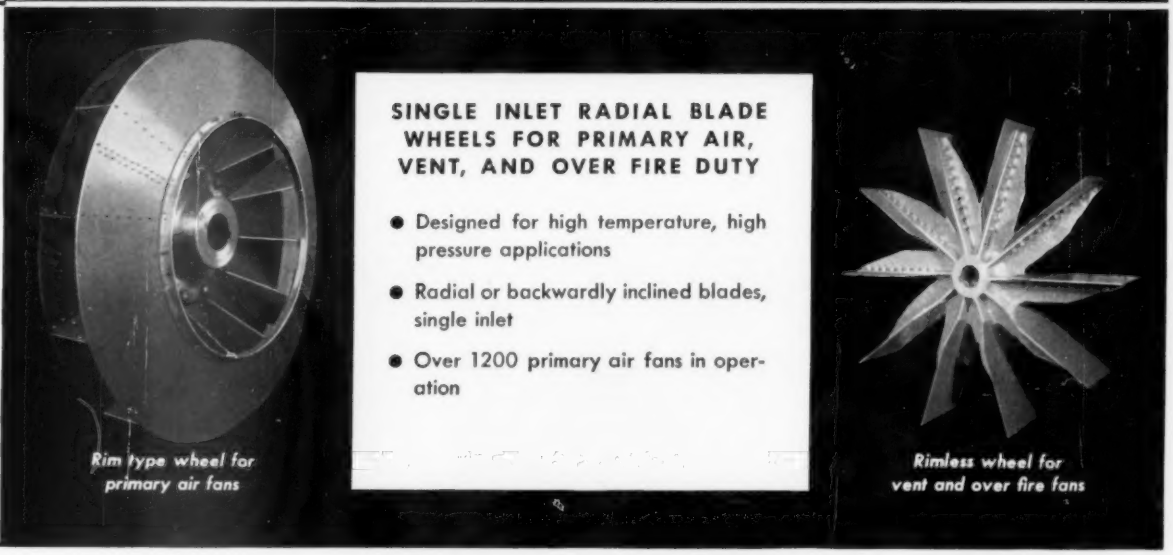
AIRFOIL BLADE WHEELS

primarily for forced draft duty

- Blades are of airfoil cross section, die formed and reinforced as required
- High mechanical and static efficiency
- Nonoverloading power characteristic
- Available with vanes and/or boxes

Meet Peak Efficiency Standards


RADIAL BLADE WHEELS
for forced, induced and gas recirculating duties
● Pressure characteristic favorable to gas recirculating application where unusual system pressures prevail
● Designed for severe temperature and pressure duty
● Available with straight radial or radial tip blades
Radial tip blade wheel
Straight radial blade wheel


SINGLE INLET RADIAL BLADE WHEELS FOR PRIMARY AIR, VENT, AND OVER FIRE DUTY
● Designed for high temperature, high pressure applications
● Radial or backwardly inclined blades, single inlet
● Over 1200 primary air fans in operation
Rim type wheel for primary air fans
Rimless wheel for vent and over fire fans

If your plans include mechanical-draft equipment—for new installations or as replacements—consult your American Blower sales engineer. He can give you helpful information on job-fitted American Blower equipment to meet your power-plant requirements. Call our nearest branch office or write: American Blower Division of American-Standard, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ont.

AMERICAN BLOWER

Division of AMERICAN-Standard

QUALITY PROTECTS YOUR INVESTMENT . . AMERICAN-Standard QUALITY IS AVAILABLE AT NO EXTRA COST

Vulcan T-30 long cover record at Meramec Station!

This Vulcan T-30 long retractable soot blower has been in operation on Unit 1 at Meramec Station since May, 1956. Fuel for the Combustion Engineering boiler is pulverized coal. Burners are arranged for tangential firing and can be tilted for superheat control.

C-3447

retracts distance

A Vulcan T-30 long retractable soot blower is reaching more than 35 feet between two banks of the pendent secondary superheater on Boiler No. 1 in Meramec Station of Union Electric Company of Missouri. This Vulcan T-30 requires only one outboard hanger to support the extra-rugged framework. Lance travel and rotation are non-synchronized through two driving motors to produce a multi-helix cleaning path to cover different areas of the tube bank while extending and retracting.

Performance of this Vulcan T-30, which is located at the furnace exit where temperatures average 1910 degrees F., led to the selection of Vulcan T-30 blowers with 36-foot travel, RW-3E wall deslaggers and E-4-E rotaries—all under automatic-sequential control—for Meramec's new Unit 3, a Foster Wheeler boiler with separate furnaces, rated at 1,850,000 pounds per hour at 2150 psig and 1010 degrees F., with reheat to 1010 degrees F.

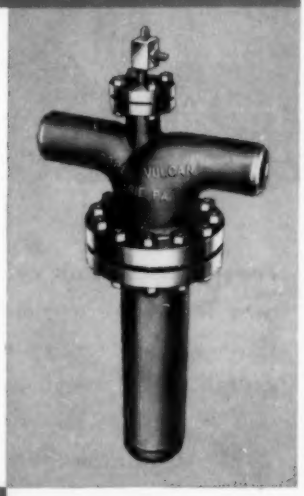
Whether your boiler is large or small, power or process, modern Vulcan soot blowers will help keep it operating at peak efficiency. Your Copes-Vulcan representative has the ideas, information and experience to help you choose the system best suited to your needs.

COPES VULCAN

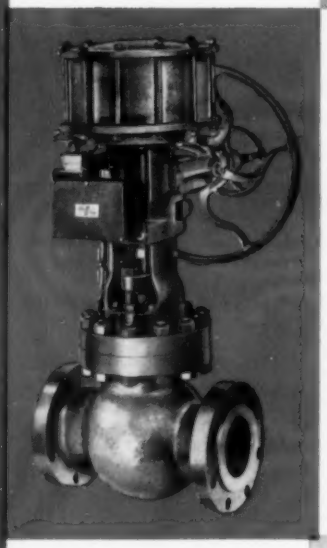
BLAW-KNOX

COPES-VULCAN DIVISION
BLAW-KNOX COMPANY
ERIE 4, PENNSYLVANIA

C-V NEWS NOTES



Copes-Vulcan Steam-Assist Desuperheater meets all specifications for conventional steam-atomizing type, yet normally uses assisting steam only on light loads where control is most difficult. Furnished with carburetor body as shown, or for in-line installation. Simple mechanical-atomizing types are also available. Bulletin 1024-A.



Unlimited pressures and sizes up to 16-inch, plus simplified design, are features of the new Copes-Vulcan Types CV-D and CV-P valves. Either diaphragm or piston types are available for pressure, temperature or liquid level control. Bulletin 1027.

Bulletin 1030 illustrates and describes the Vulcan T-30 long retractable soot blower, now successfully operating in temperatures up to 2150 degrees F. (radiant). Your Copes-Vulcan representative can give you a copy, or write direct to the factory.

For The Ultimate in FLY ASH COLLECTION Be Sure It's...

WESTERN PRECIPITATION *First* in Electrical Precipitators

Power plant operators who want the finest equipment available for fly ash collection will find nothing to equal the long life, high efficiency and low maintenance of *Western Precipitation* Electrical Precipitators.

The reason is simple – No other electrical Precipitator is backed by so many years of leadership in the field – nor incorporates so many outstanding advantages pioneered by the industry's most experienced organization in the development of Cottrell equipment – experience beginning with the world's first commercial Cottrell installation!

This cross-section of a typical Western Precipitation Electrical Precipitator shows a few of the many important details that go into the construction of these units...

CONSTRUCTION FEATURES

▶ Arrangement of curtains (1), baffles and hi-voltage wires (2) assures optimum uniformity of electrical field – therefore maximum collection efficiency.

▶ Baffles (3) insure minimum dust reentrainment and optimum gas distribution.

▶ Curtains and hi-voltage system are engineered for maximum stability, even distribution of rapper impact, and unequalled ease of installation.

▶ No moving parts in the gas stream.

▶ Supports (4) for hi-voltage system are specially designed to resist side thrusts, and require minimum maintenance.

▶ Internal stiffeners permit clean, smooth external surfaces for easy insulation (5).

▶ Air-swept insulator compartments (6) insure long life, minimum maintenance.

▶ Unobstructed free-flowing hoppers (7) permit complete dust evacuation.

ADVANCED RAPPER DESIGN

▶ Frequency and intensity of rapping is variable over wide ranges to eliminate puffing and meet individual operating requirements.

▶ All rappers (8) are external for easy adjustment and maintenance.

▶ Flexible mounting – either side or top.

SAFETY ENGINEERED

▶ Hi-voltage insulators (9) are protected by separate compartments with individual access (10).

▶ Quick-opening access (11) doors are positive-sealing.

▶ Complete interlock system available at minimum cost.

"TRANSISTOMATIC" PRECIPITATOR CONTROL

▶ No tubes, no relays, no moving parts – *carries lifetime guarantee!*

▶ *Infinitely* variable precipitator voltage to suit operating conditions.

▶ Automatically compensates for line voltage fluctuations.

Before finalizing plans for installing any dust or fly ash collection equipment, get the full story on the finest collection equipment available – Western Precipitation Cottrells!

WESTERN PRECIPITATION CORPORATION

Engineers and Constructors of Equipment for Collection of Suspended Material from Gases . . . and Equipment for the Process Industries

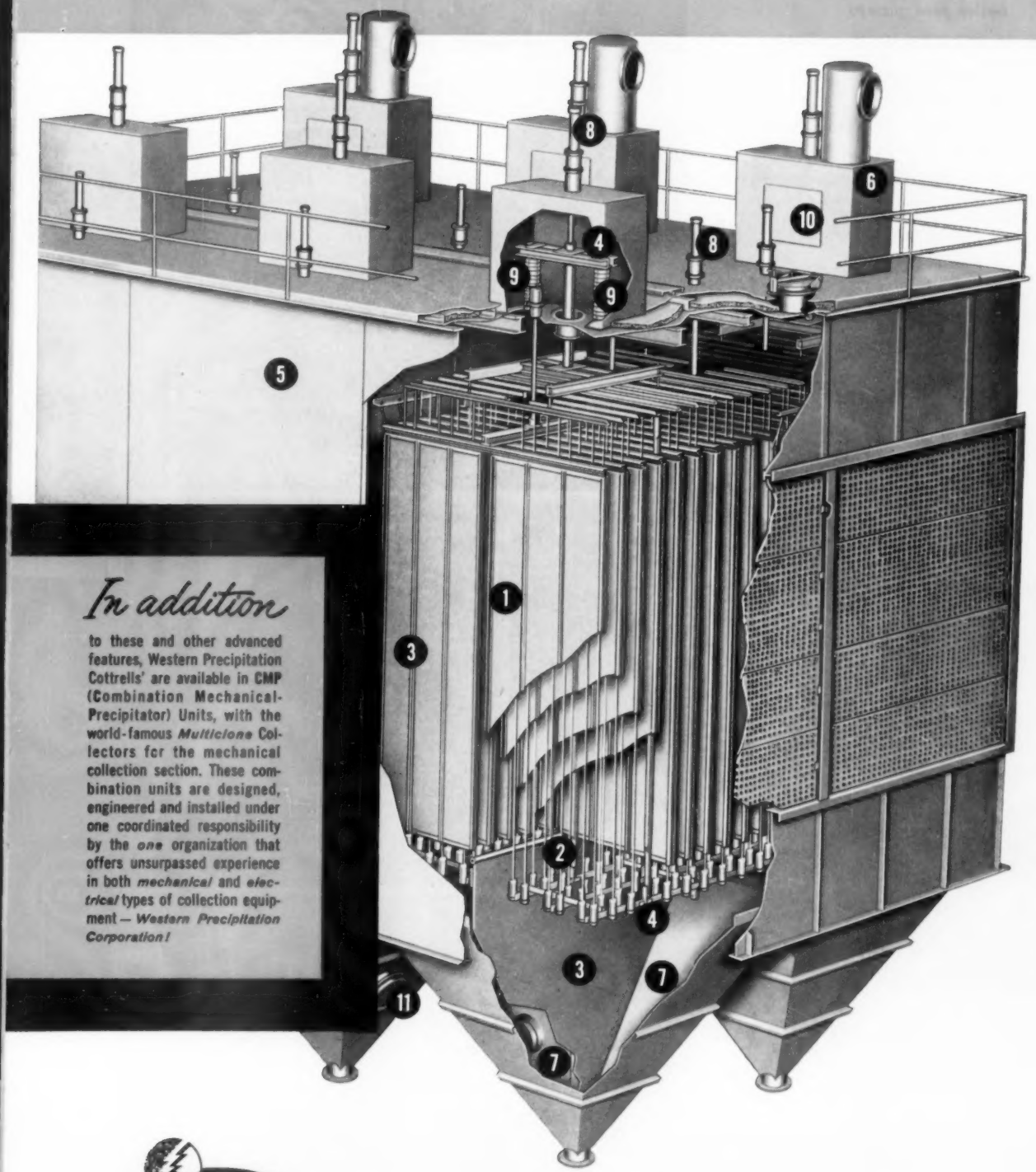
LOS ANGELES 54 • NEW YORK 17 • CHICAGO 2 • PITTSBURGH 22 • ATLANTA 5 • SAN FRANCISCO 4

Representatives in all principal cities

Precipitation Company of Canada Ltd., Dominion Square Bldg., Montreal

The only equipment backed by a

Half-Century of Cottrell Experience



In addition

to these and other advanced features, Western Precipitation Cottrells' are available in CMP (Combination Mechanical-Precipitator) Units, with the world-famous *Multiclone* Collectors for the mechanical collection section. These combination units are designed, engineered and installed under one coordinated responsibility by the *one* organization that offers unsurpassed experience in both *mechanical* and *electrical* types of collection equipment — *Western Precipitation Corporation!*

REMEMBER—*in the field of dust collection, nothing equals the long life, low maintenance and high collection efficiency of a Cottrell Electrical Precipitator!*

1. Barrel type boiler feed pumps

2. Centrifugal compressors

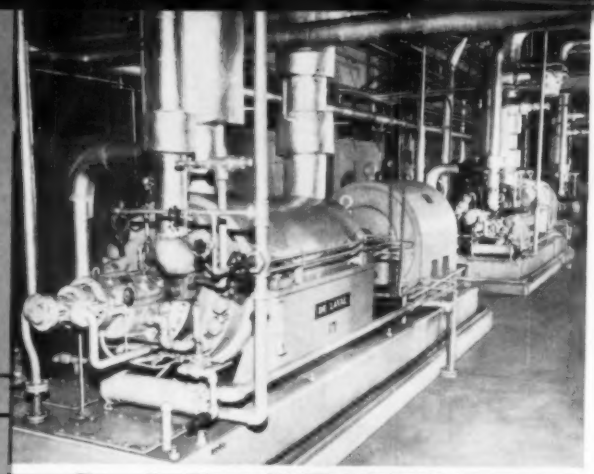
3. Centrifugal pumps for many services

4. De Laval IMO pumps for fuel oil transfer

5. De Laval IMO pumps for fuel oil burner service

6. Multi-stage turbine generators

1



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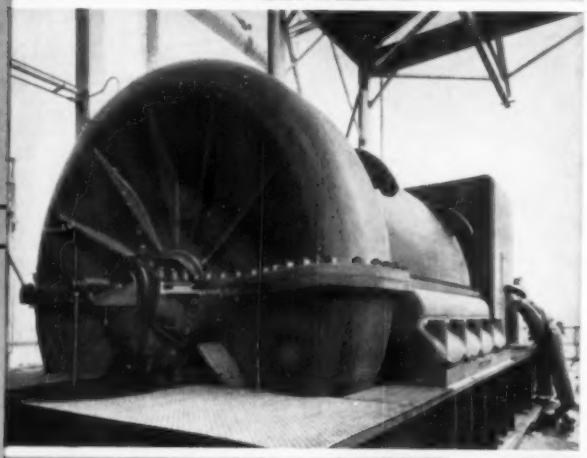

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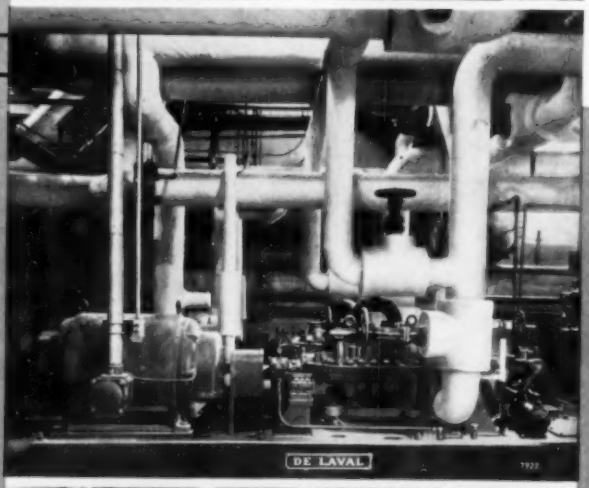

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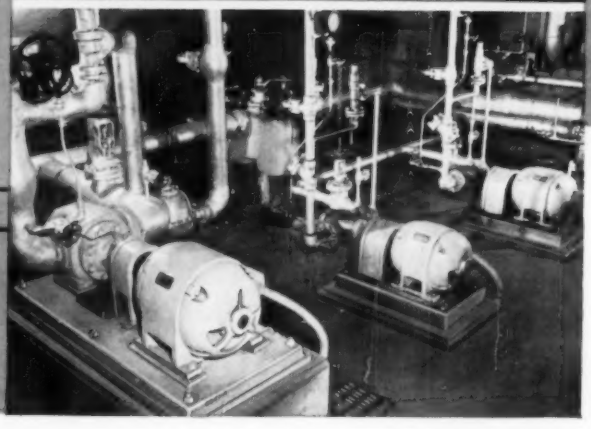

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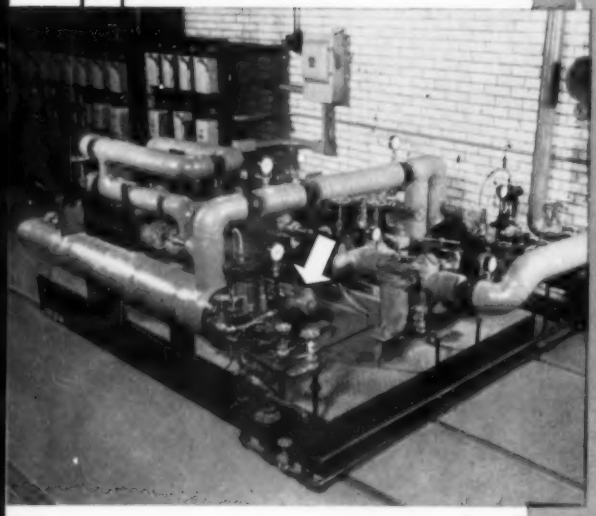
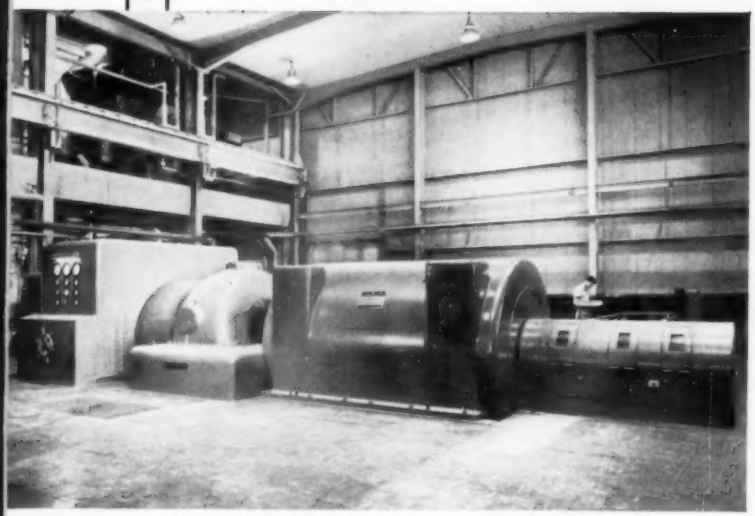


DE LAVAL

designs for dependability

6



Machines
that *stay* in service
year in and year out
are the most economical.
Since 1901,
De Laval has supplied
quality-designed pumps,
compressors, and other
vital equipment for the
power industry.
Each unit is designed
for dependability and
built by master craftsmen.
As a result, the De Laval
name plate is your
assurance of reliability.
Literature is available
on all equipment
shown on these pages.

DE LAVAL Steam Turbine Company

886 Nottingham Way, Trenton 2, New Jersey

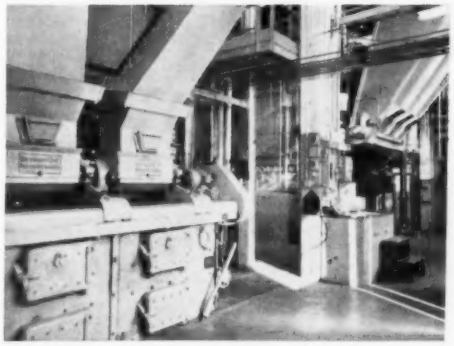
DL 311

Carlisle Tire
CARLISLE TIRE &

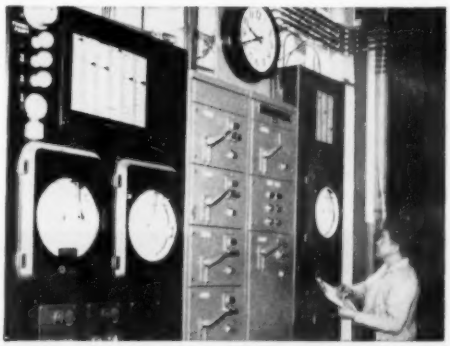
takes fuel costs for a ride

With increased fuel efficiency, Carlisle Tire and Rubber burns coal . . . holds costs to minimum while upping production 20%

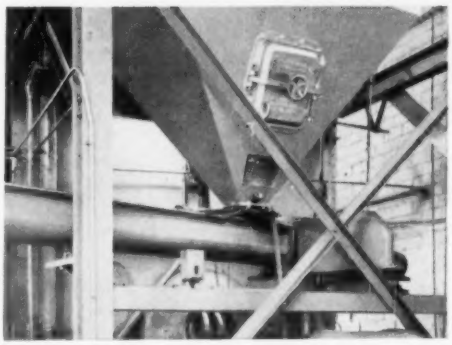
At the Carlisle Tire and Rubber Division of Carlisle Corp., Carlisle, Pa., the steam produced by the power plant is used primarily for processing. As production of bicycle tires, inner tubes and other rubber products increased, the firm's engineering department decided to boost steam capacity with modern coal-burning facilities. Coal was used on the basis of cost—25% less than the nearest competitive fuel. The result has been a dependable steam supply, cleanliness of operation and a jump in operating efficiency. Today the plant consumes the same tonnage of coal as before modernization although production has increased 20%!



Firing aisle of Carlisle's power plant. Left foreground is new 20,000 lbs./hr. boiler by E. Keeler Co., fired by Detroit Rotostokers. In the rear is an Erie City Water Tube Boiler (equipped with Erie City Spreader Stokers), used as stand-by unit.



Close-up of control panel, by Hagan Corp. These controls—regulating furnace draft, steam flow, air flow, flue gas temperature, stoker control—constitute a complete, automatic combustion control system.



Fly ash is collected by this Prat-Daniel Mechanical Precipitator. Fly ash is gravity-fed from the hopper (at top of photograph) into completely-enclosed screw conveyor which moves it cleanly to the disposal point.

Facts you should know about coal

Not only is bituminous coal the lowest-cost fuel in most industrial areas, as in the case of Carlisle, but up-to-date coal burning equipment can give you 10% to 40% more steam per dollar on the average. Today's automatic equipment pares labor costs and eliminates smoke problems. And vast coal reserves plus mechanized production methods mean a constantly plentiful supply of coal at stable prices.

Technical advisory service

The Bituminous Coal Institute offers a free technical advisory service on industrial fuel problems. We welcome the opportunity to work with you, your consulting engineers and architects. If you are concerned with steam costs, write to the address below. Or send the coupon below for our case history booklet, complete with data sheets. You'll find it informative.

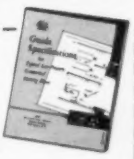
Consult an engineering firm

If you are remodeling or building new heating or power facilities, it will pay you to consult a qualified engineering firm. Such concerns—familiar with the latest in fuel costs and equipment—will effect great savings for you in efficiency and fuel economy over the years.

BITUMINOUS COAL INSTITUTE

Southern Building • Washington 5, D.C.

The Bituminous Coal Institute now has available a free booklet, "Guide Specifications for Typical Low-Pressure Commercial Heating Plant," containing specifications, drawings and tables on all aspects of a typical heating plant. Send in this coupon for your copy.



Please send me: ☐ Guide Specifications booklet ☐ Case history booklet

Name .....

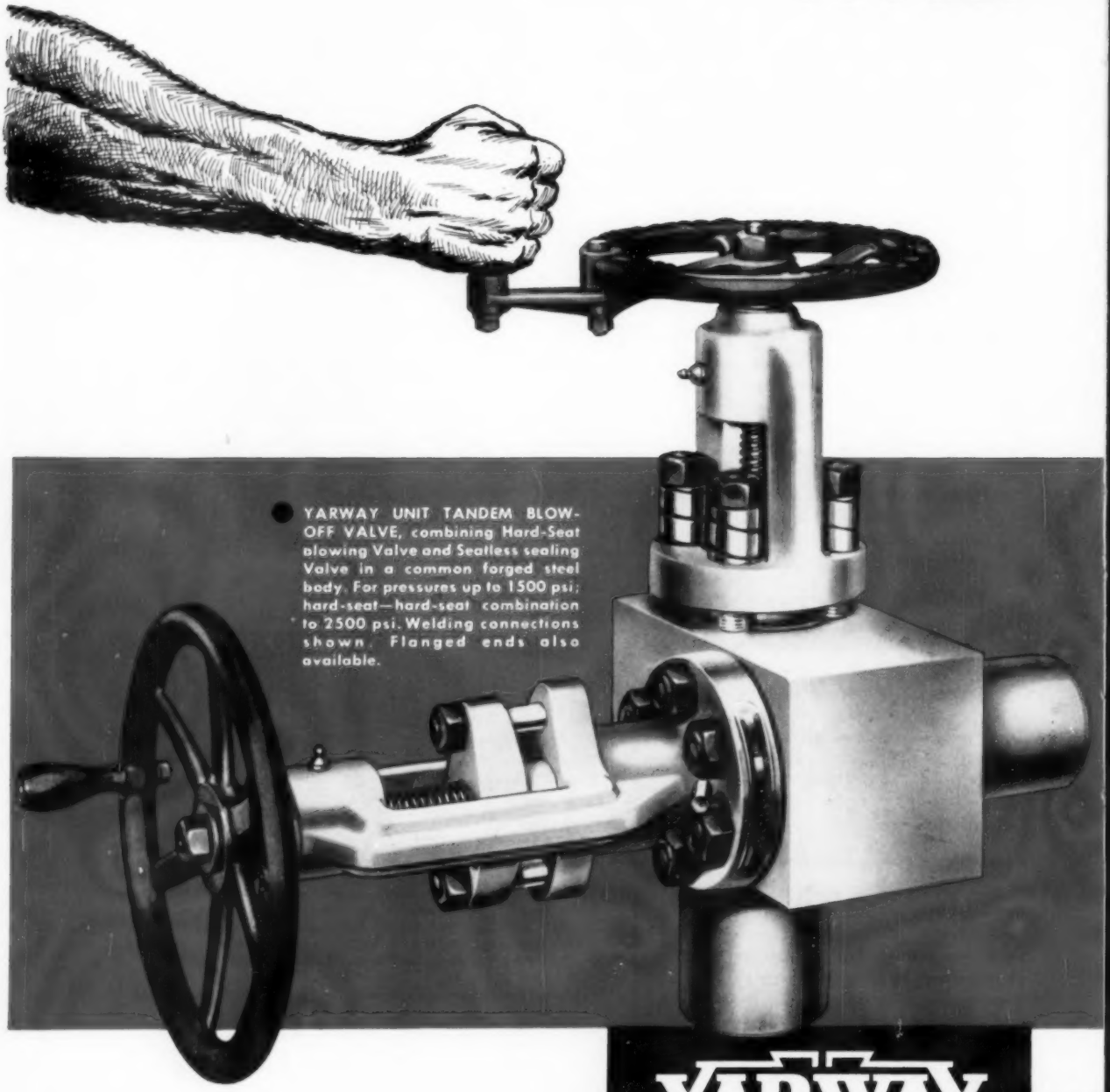
Title .....

Company .....

Address .....

City ..... Zone ..... State .....

rugged ... for



● YARWAY UNIT TANDEM BLOW-OFF VALVE, combining Hard-Seat blowing Valve and Seatless sealing Valve in a common forged steel body. For pressures up to 1500 psi; hard-seat—hard-seat combination to 2500 psi. Welding connections shown. Flanged ends also available.

YARWAY

rugged blow-down service

YARWAY UNIT TANDEM BLOW-OFF VALVES

When boiler pressures are high you may not "blow-down" very often, but, man, when you do, you're glad those blow-off valves are rugged YARWAY Unit Tandems!

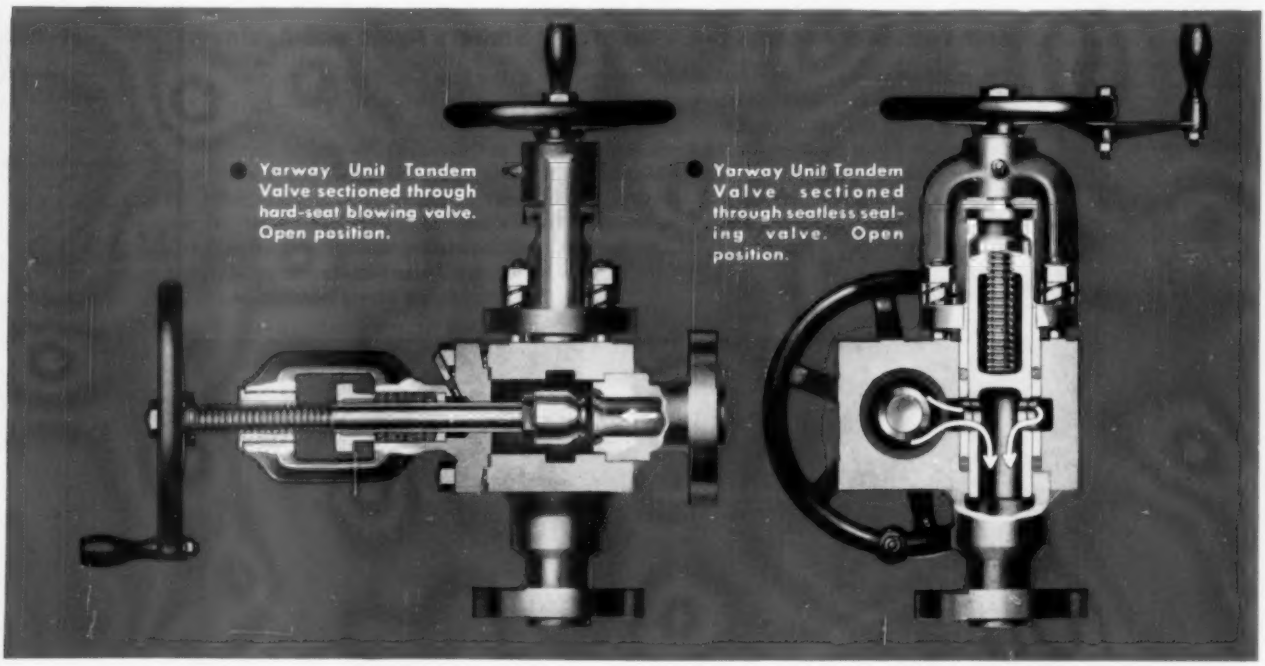
More than 80% of high pressure boiler plants are equipped with YARWAY *Blow-Off Valves*, and there's ample reason.

YARWAYS are strong, heavy-duty valves giving the important extra dependability needed for the severe combination of high pressures (hence high velocities), acid cleaning, and abrasion caused by precipitated solids.

YARWAY Blow-Off Valves also are relied upon to keep boiler level within desirable limits during quick starts of high pressure boilers.

Specify YARWAYS—to protect *your* boilers. Write for Bulletin B-434.

YARNALL-WARING COMPANY
100 Mermaid Ave., Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES


Yarway Unit Tandem Valve sectioned through hard-seat blowing valve. Open position.
Yarway Unit Tandem Valve sectioned through seatless sealing valve. Open position.

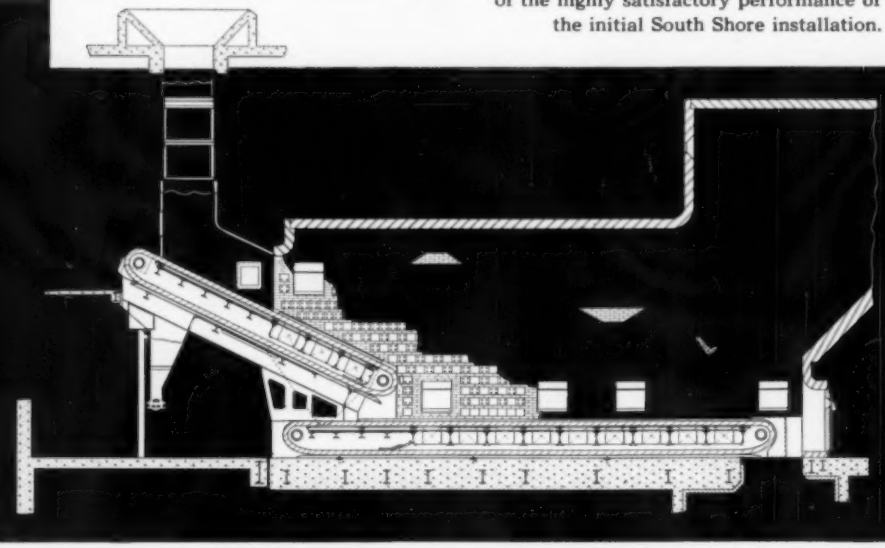
— blow-off valves

THE C-E INCINERATOR STOKER . . .

The best way to

New York City Accepts C-E Incinerator Stokers Again and Again

These illustrations – above and below – show one of the four C-E Stoker equipped furnaces in New York's South Shore Incinerator Plant in Brooklyn which have been in service since 1954. Duplicate installations are on order for the city's new Greenpoint Plant and also for the Betts Avenue Plant in Queens. Three similar units are in service in the 73rd St. Plant in Manhattan. That is fifteen units – 30 stokers – in all. The fact that the New York City Department of Public Works . . . which designed these plants, and the Department of Sanitation which operates them . . . have approved this equipment again and again for their expanding needs is indicative of the highly satisfactory performance of the initial South Shore installation.



burn municipal refuse

The C-E Incinerator Stoker has numerous points of superiority but the foremost of these is its perfect suitability to the "*continuous*" process of refuse incineration. There is a tremendous saving in the labor required for operation over that necessary for the widely used "*batch*" process.

From the time the refuse is deposited into the self-sealing, non-clogging, feed hopper until the incinerated residue is ready to be hauled away, only minimum operating attention is required. A comparison between a C-E equipped "continuous" process furnace and any contemporary "batch" process installation will prove a revelation to anyone concerned with the problems of refuse disposal.

The decontaminated refuse as it comes from the C-E Incinerator Stoker provides a sanitary inoffensive fill for reclamation of waste lands, swamps and other recoverable areas.

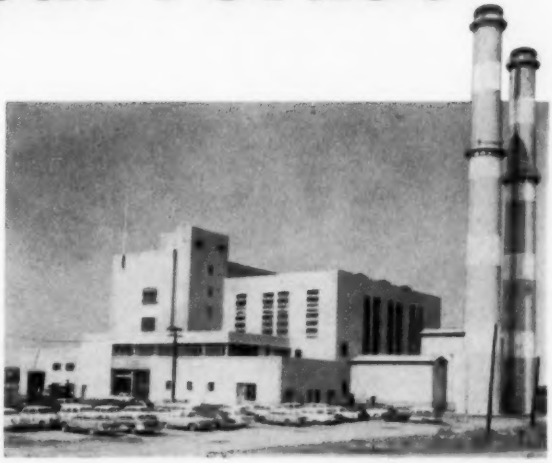
Where there is need for steam for heating, power or process, the addition of a waste heat boiler to utilize the heat produced by the incinerator provides an exceptionally desirable and economical arrangement. Auxiliary oil-firing equipment can be supplied to assure continuity of steam output irrespective of incinerator load.

The C-E Incinerator Stoker is designed to handle all types of combustible refuse in quantities ranging upward from 50 tons per 24-hour day.

For further information, please contact the Combustion office in your city or write directly to Combustion Engineering, Inc., 200 Madison Avenue, New York 16, N. Y.

INDUSTRIAL REFUSE

Get rid of *industrial refuse*, too, with the C-E Incinerator Stoker. Add a Waste Heat Boiler if additional steam is required.



New York City's South Shore Incinerator Plant where four furnaces equipped with C-E Incinerator Stokers have been in service for three years.

HIGHLIGHTS OF C-E DESIGN

- Large hopper and chute provide sealed, continuous supply of refuse.
- Unobstructed, non-clogging feed of refuse.
- Continuous, positive advance of fuel bed from front to rear.
- Zone control of air to fuel bed.
- Continuous discharge of residue from grate surface.
- Easy to operate—no heavy stoking or cleaning of fires.
- Chrome cast iron — most suitable material — used for grate surface.
- Wide keys over driving chains prevent fouling.
- Easily replaceable grate elements.
- Steel driving chains take all tension.
- Take-up mechanism easily accessible at front.
- Assures maximum availability.
- Provides most economical method of disposal.
- Applicable to largest incinerators.
- Requires less labor than any other burning method.

COMBUSTION ENGINEERING

Combustion Engineering Building, 200 Madison Avenue, New York 16, N. Y.

C-108A

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT; NUCLEAR REACTORS; PAPER MILL EQUIPMENT; PULVERIZERS; FLASH DRYING SYSTEMS; PRESSURE VESSELS; SOIL PIPE

WHAT'S SPECIAL ABOUT LJUNGSTROM®

structural details?

. . . many things.

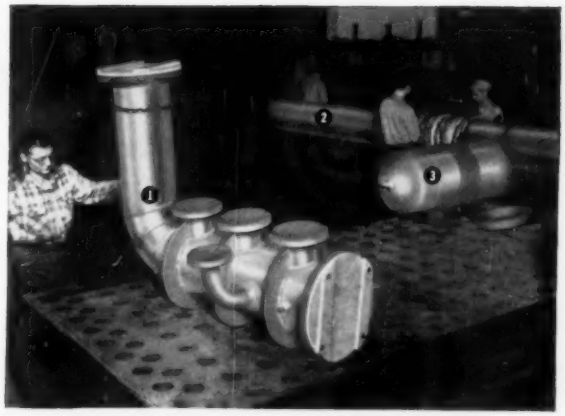
And all make air preheating with a Ljungstrom more economical, less troublesome. The Ljungstrom offers these refinements:

- The welded steel rotor is strong enough to support the heating elements without strain, yet flexible enough to withstand extreme temperature variations.
- An inspection port and strategically located access doors reveal any maintenance needs and make replacement work routine.
- A mass flow soot blower is installed as original equipment at the cold end where deposits are most apt to accumulate.
- The hot end heating surface is made from open hearth steel sheet and the cold end from heavier gauge, low-alloy corrosion-resisting material because corrosion is normally confined to the cold end.

The Air Preheater Corp. is constantly working to improve Ljungstrom heating surfaces, seals, bearings, and other structural details. And, in general, these improvements can be applied to existing units with only minor changes and at nominal cost. Another reason why seven out of ten air preheating installations are Ljungstrom. For the full story on how the Ljungstrom design and construction can cut your fuel costs, increase plant efficiency, write for our 38-page manual.

The Air Preheater Corporation, 60 EAST 42ND STREET, NEW YORK 17, N. Y.

ALL IN A DAY'S WORK at *Pittsburgh Piping*



These three jobs are typical of the wide variety of custom piping work which we do for the power and process industries. In the background of the photo welders are shown making the heli-arc root pass on 18" O.D., 3.875" wall, chrome-moly main steam piping. In the foreground, ready for final inspection, is a 12" header for a process operation, fabricated of ⅜" aluminum alloy. The pressure vessel, of austenitic steel, is one of many we produce for atomic energy application. The manufacturing of this type of piping requires specialized facilities . . . for engineering, fabricating, testing, assembly, and erection. We have those facilities. Use them on your piping jobs.

Promoting Progress **IN POWER AND PROCESS PIPING**

Pittsburgh Piping **AND EQUIPMENT COMPANY**
158 49th Street—Pittsburgh, Pa.

Canada: **CANADIAN PITTSBURGH PIPING, LTD.,** 835 BEACH ROAD—HAMILTON, ONTARIO

Atlanta	*Whitehead Building*	*Hollywood*	*1828 North Alexandria Ave.*
Boston	*10 High Street*	*New Orleans*	*P. O. Box 74*
Chicago	*Peoples Gas Building*	*New York*	*Woolworth Building*
Cleveland	*Public Square Building*	*Syracuse*	*113 So. Salina Street*
		Toronto	*68 Yonge Street*

THE BAYER CO.

MANUFACTURERS OF BAYER SOOT BLOWERS

For Highest First and Final Value

. . . BUY BAYER!

BAYER

Balanced Valve

SOOT CLEANER

Bayer's single-chain design compels perfect in-step operation of valve and element. Operation is positive, definite, assuring a full flow of steam for efficient cleaning.

When the operator pulls chain, the cam-actuated, quick-action balanced valve is opened. By continued pulling of the chain, worm drive slowly rotates element over cleaning arc. When element reaches end of cleaning arc, valve automatically closes.

Minimum steam consumption—low maintenance. Every detail is engineered, built for long life, efficient performance at high temperatures and high pressures.

More than 30,000 boilers are Bayer equipped. More than 45 years' successful, specialized experience assures you investment economies in Bayer equipment.

QUALIFIED LOCAL ENGINEERING SERVICE—Your Bayer representative is an experienced engineer, well qualified to take care of any service needs in connection with Bayer Soot Cleaners. He is available when you call upon him and will gladly render any service required.

All These Mechanical and Operating Advantages are available in

The BAYER *Balanced Valve* SOOT CLEANER

1. **Sound engineering, workmanship, and materials of the best.**
2. **An organization of over 45 years' experience, capable and willing to render service at all times.**

SINGLE CHAIN: Valve and element controlled by a single chain.

VALVE BODY: Rugged construction, built to last. Short and ample steam passage giving very small pressure drop.

ORIFICE PLATE VALVE: For high pressure service, each head may be controlled by an orifice plate valve through which pressure is adjusted for each individual element.

STUFFING BOX: Due to maintenance of perfect alignment on swivel tube, packing needs little attention. Stuffing box is in full view, readily accessible.

AIR SEAL: Has machined surface on wall sleeve and spring-held floating seal to prevent air in-leakage.

HEAD BEARINGS: There are two main bearings, an outboard and an inboard bearing for the swivel tube to maintain alignment.

THRUST BEARING: Ring type thrust bearing takes the load.

VACUUM BREAKERS: Two vacuum breaker air valves, or one valve and a signal whistle above each valve, to prevent suction of boiler gases into valve and piping.

ELEMENT OPERATION: With the Bayer element operation, balanced valve is opened just as element rotates, giving FULL pressure over entire cleaning arc. Full steam pressure insures thorough cleaning. Balanced valve saves wear of valve parts. With any type of poppet valve, this is important. . . ask any operator.

BLOWING ARC: Valve cams automatically regulate cleaning arc.

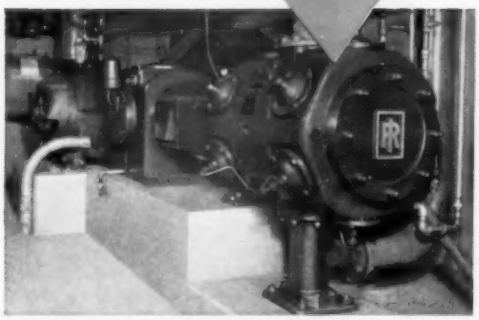
REDUCTION GEARS: 24 to 1 gear ratio gives slow rotation for good cleaning.

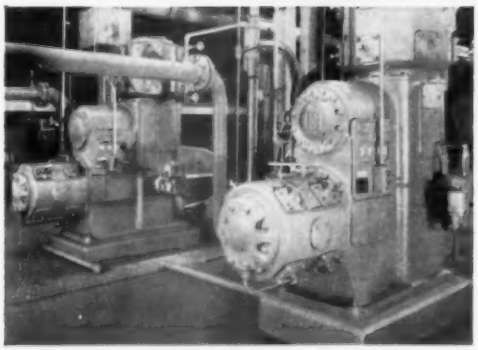
FLANGED PIPE CONNECTION: Operating head is connected to supply pipe by flanges and through bolts, or high tensile studs and nuts.

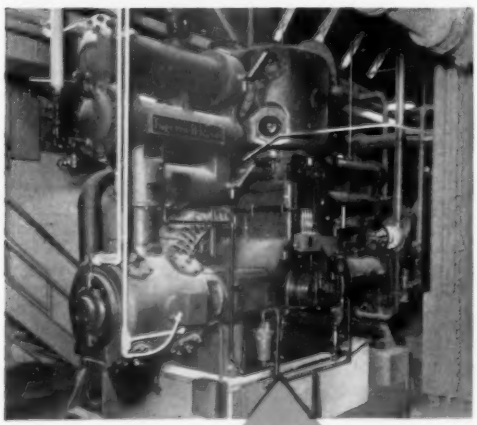
THE BAYER CO.

St. Louis, Mo.

THE RIGHT COMPRESSOR
for EVERY Power Plant application







Compressors designed
FOR THE JOB operate
most dependably and economically

for INSTRUMENT AIR
ESH-NL Compressors 20 to 150 hp

Ingersoll-Rand heavy-duty Class ESH compressors with NL (non-lubricated) cylinders meet the most exacting instrument-air requirements—dependability, continuity of service and *oil-free air.* The NL piston is fitted with graphitic-carbon supporting and pressure rings, requiring no oil, grease, water or glycerine for lubrication.

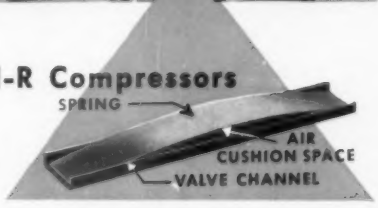
for GENERAL SERVICE AIR
XLE Compressors 125 to 350 hp

The XLE is a two-stage, electric-driven, heavy-duty compressor. The proven design, using full-floating aluminum bearings, and thru-frame air flow with packaged intercooler, makes the XLE a logical choice wherever a dependable supply of service air is required. Maintenance and operating costs are low. The machines are easy to install, requiring only a minimum of foundation because of their excellent running balance.

for SOOT BLOWING
TVH Compressors 200 to 450 hp

These three-stage compressors have been specifically developed for heavy-duty soot-blowing service at pressures from 350 to 500 psi. Inverted "T" design, with self-contained intercooling assures high overall efficiency, low discharge temperatures and smooth running balance.

Only I-R Compressors



have CHANNEL VALVES

I-R Channel Valves are known the world over for their high efficiency, remarkable durability, long service life and freedom from maintenance. On opening, the valve channel lifts upward against spring pressure—trapping a cushion of air between the channel and spring. This exclusive air-cushioned design cuts impact shocks, reduces wear and assures quiet operation.

NL Channel Valves for non-lubricated cylinders are the only valves designed specifically for this service, with no metal-to-metal sliding or rubbing surfaces, assuring sustained high efficiency and longer valve life.

For a quick solution
to any compressor problem,
call your I-R representative

Ingersoll-Rand

I-693

11 Broadway, New York 4, N. Y.

COMPRESSORS • CONDENSERS • AIR AND ELECTRIC TOOLS • TURBO-BLOWERS • PUMPS • ROCK DRILLS • GAS AND DIESEL ENGINES

J.C.P. & L.'s New Sayreville Addition to have HAGAN INSTRUMENTS AND CONTROLS

Jersey Central Power & Light Company is well acquainted with Hagan controls. Their E. H. Werner Station, South Amboy, New Jersey addition is equipped with Hagan Automatic Combustion Control, 3-Element Feedwater Control, and Hagan Ring Balance meters. Base-loaded, their 62,500 kw addition has been on automatic control since it began operation in 1953. Hagan was again selected for the new boiler addition at the Sayreville Station, Sayreville, New Jersey.

Jersey Central Power & Light's E. H. Werner Station. The most recent unit, shown at the left, is fired by two Cyclone furnaces, the first to be installed in the Eastern United States.

At Sayreville, Hagan equipment will include Combustion Control, 3-Element Feedwater Control, Feedwater Pump Recirculation Control, Principal Metering and Panels. In general, the systems will follow the pattern established at the E. H. Werner Station since the boilers at both stations are fired by Cyclone furnaces, two at Werner and four at Sayreville. The Sayreville boiler will operate to produce 900,000 lbs of steam per hour at 2050 psig and 1050 F with reheat at 1000 F.

Both management and operating personnel are satisfied with the reliability, accuracy and low maintenance costs made possible by Hagan control systems. Why not take advantage of the problem-solving skills developed by more than 35 years of experience with boilers of all types? A Hagan engineer will be happy to work with you on the design of controls for new plants or plant expansions. Write or phone:

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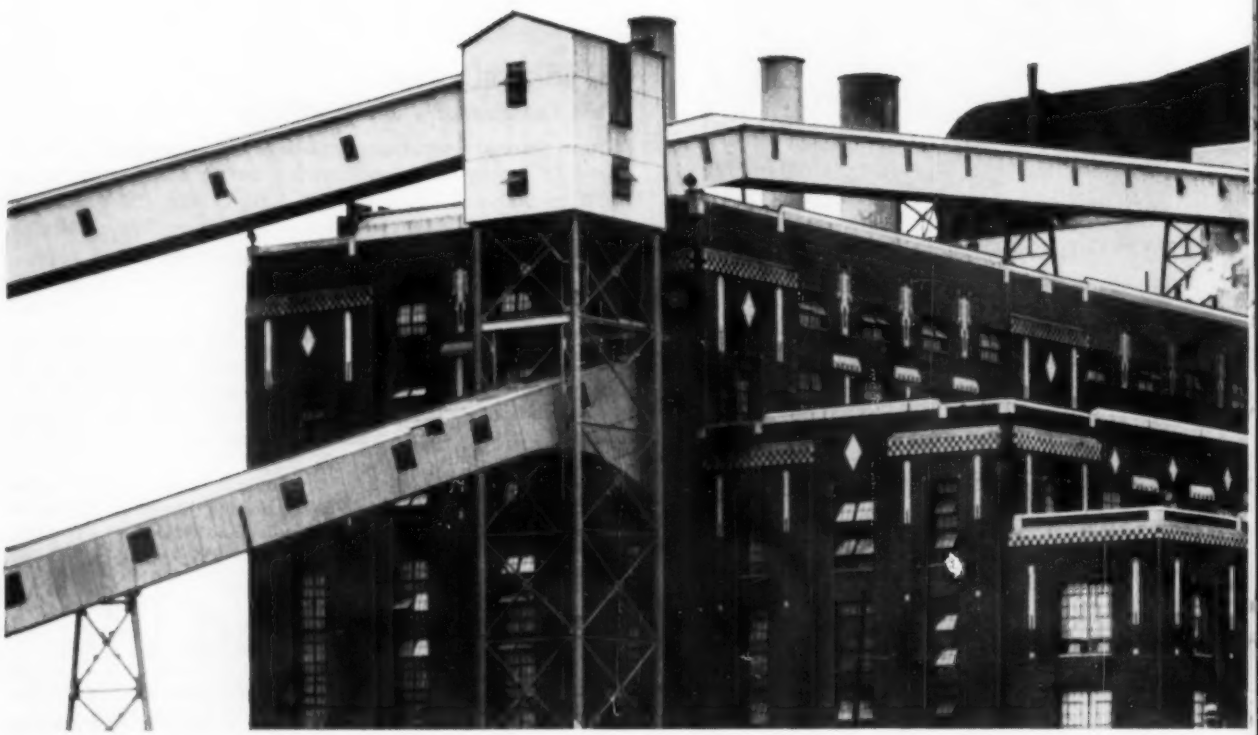

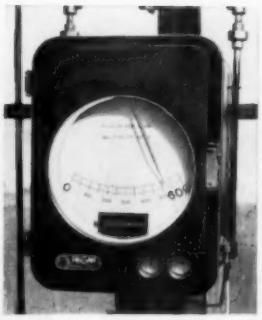

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Steam Flow Transmitter. The signal from this instrument is combined in a Hagan Ratio Totalizer with the signal from the Feedwater flow meter to hold these two variables in proper relationship during load changes. The inherent accuracy of the Hagan Ring Balance together with the unique spring resistance system permits easy range change, and more precise measurement of low flows.

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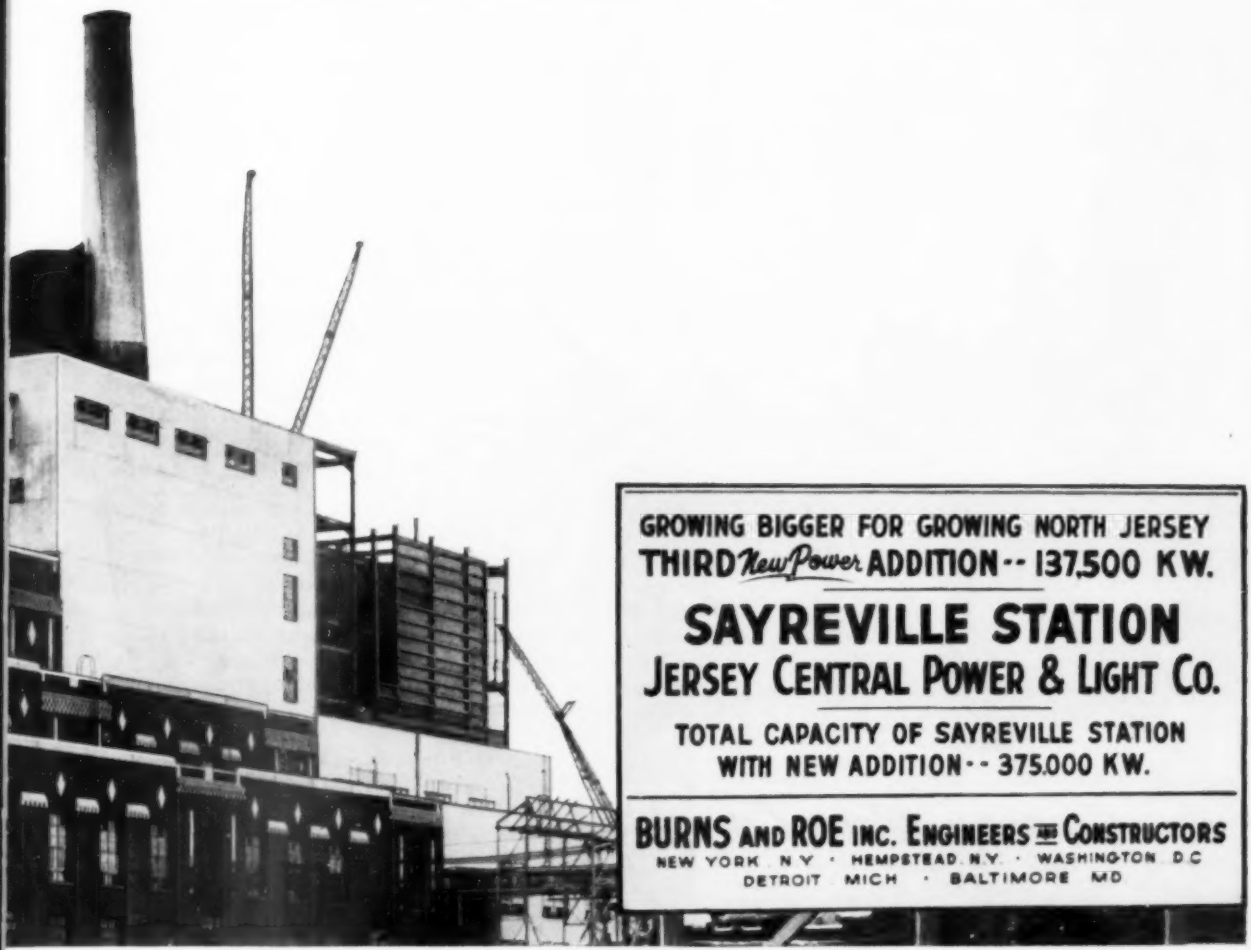
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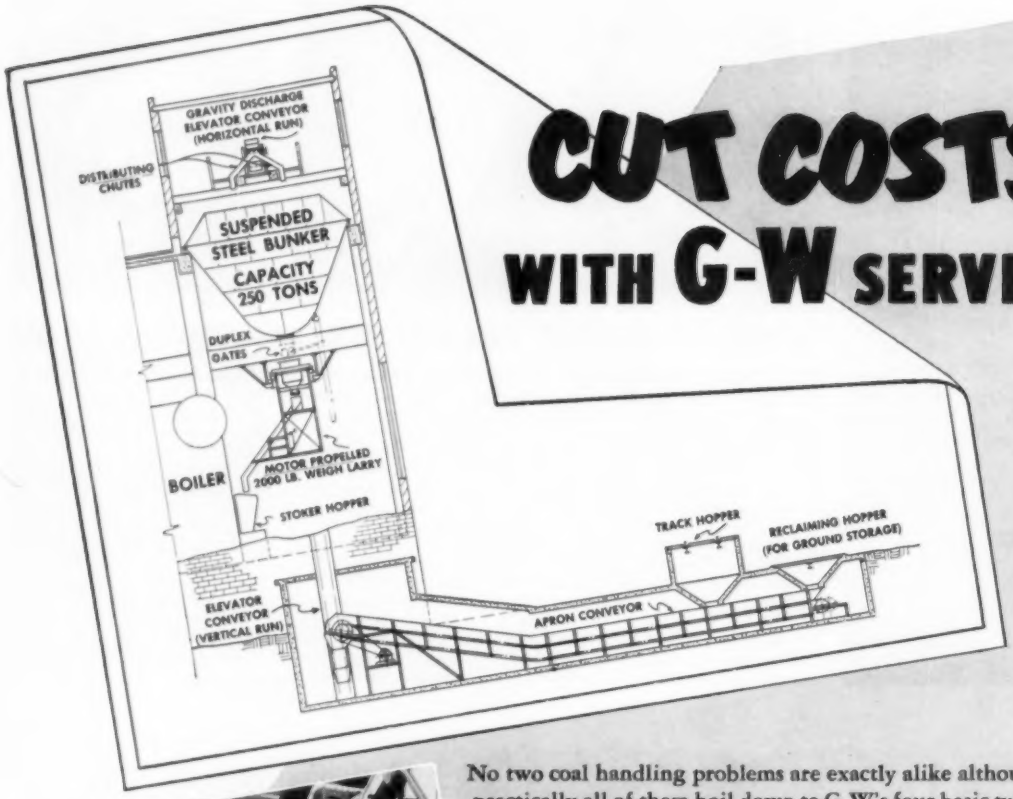

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Editorial

The War of Words

All of us are aware of the torrent of words now issuing from the popular press on our national shortcomings in science and in education. There is in most of these words just a repetition of the theme that we have been gliding along, resting on our laurels. Fortunately, there are some who think a little deeper and go beyond the solution advocated by the queen of Alice In Wonderland fame, namely, "off with his head."

At the dedication ceremonies for the Navy's Nuclear Power Training School at New London, Admiral Rickover came to grips with the education picture in our country today. We quote, "I think we have come to the pass we are in today because our mass media wrap us in a cocoon of soothing 'Coue-ism' along the lines of 'every day and in every way things are going to be better and better.' Few of us read serious books. We are, therefore, singularly defenseless against the continuous flood of optimistic predictions of a future with delightful superabundance—just around the corner—which American science will provide. . .This silky cocoon has kept us in isolation from the educational practices of even our closest allies in Europe. A few hours' check of their curricula, teaching standards, and of the end results of their educational system would disabuse us speedily of our illusions. . . .

"Let me condense it (what is wrong with American education) to a few major points. For greater details, I can think of no better source of information than the Hearings on the 'Shortage of Scientific and Engineering Manpower' held before the Subcommittee on Research and Development of the Joint Committee on Atomic Energy of the Congress of the United States. These Hearings were held in April and May 1956, under Chairmanship of the Honorable Melvin Price of Illinois. There, deft interrogation and high integrity and honesty brought forth all the facts which are needed to understand the problem; as well as enough good suggestions for practical reforms to undo in a reasonable length of time all the damage done our children and our future by fifty years of educational stagnation. Similar help will come from the Preparedness Investigation presently being conducted by the Senate Armed Services Committee. No American can consider himself a conscientious citizen who does not take the time and trouble to read these documents and think them through. I, myself, have found them most helpful in formulating my own ideas on American education."

To our way of thinking the above two paragraphs clearly identify the problem, suggest means of combating it and offer a collection of unbiased opinions by the more highly informed people of our country. We suggest the White House Conference on Education held two years ago in Washington amid waves of publicity be reconvened and set about the tasks of incorporating the remedies referred to above into our educational system. Action, not words, seems needed now.

The trend to variable speed boiler feed pump operation will strengthen as operating pressures continue to grow according to the author. Along with this application there are those who strongly feel the hydraulic coupling drive will supplant the feedwater regulator. The pros and cons are discussed herein.

By IGOR J. KARASSIK*
Worthington Corporation

Can Hydraulic Couplings

THE argument between proponents of variable speed operation with hydraulic couplings and advocates of the constant speed motor drive continues. But, as operating pressures continue to grow and sizes of boiler feed pumps continue to increase, the trend to variable speed operation will increase also. The reason is that savings remain essentially proportional to the size of the driver, while the initial cost of the variable speed mechanism, expressed in $/HP definitely decreases with size. Thus, for larger motors, there is greater justification to purchase a variable speed component.

But even after a decision has been made in favor of an hydraulic coupling drive, there remains the controversial question as to whether the feedwater regulator can now be dispensed with entirely or whether it still needs to be retained, throttling, it is true, only a modest pressure drop at all loads. It is this question which we wish to consider in this article.

Variable Speed Vs. Constant

We shall not attempt here to present a detailed analysis of the advantages to be derived from variable speed operation, as this formed the subject of a very complete treatise elsewhere.[1] It will be sufficient to give a very brief explanation of the basis for the comparison between constant and variable speed operation.

The pressure generated by a centrifugal pump at constant speed increases with a decrease in capacity and the rise in pressure between rated flow and shut-off conditions will range anywhere from 15 to 25 per cent in the case of a boiler feed pump. On the other hand, the pressure required to feed the boiler has the general characteristics of a system-head curve made up of a pressure (or static) and frictional components. Thus, the system-head curve decreases appreciably with a reduction in flow.

The Case for the Hydraulic Coupling

If the pump is operated at constant speed, the difference between the developed and required pressures must be throttled by the feedwater regulator, as shown on Fig. 1. (For the sake of simplicity, the drum pressure is shown as constant. Actually, the superheater outlet pressure is held constant while the drum pressure rises with flow to makeup for the superheater losses.) Generally, this is a three-element controlled valve, with the feedwater flow being balanced against the stream flow and the boiler drum level acting as the third, "trimming" impulse. Of course, if the pump can be operated at variable speed it need develop only that pressure at any capacity which is needed to overcome the pressure and friction heads at that capacity. The same three-element regulator control is employed. Only, instead of acting to position a feedwater regulator valve, the impulse from the control is used to set the position of the rod which locates the oil scoop in the hydraulic coupling. Pushing the scoop in withdraws oil from the circuit, increases the slip and slows the pump down. Withdrawing the scoop brings the pump speed back up.

To properly understand the source of the power savings under variable speed operation, it is necessary to examine Fig. 2 which shows the performance of a boiler feed pump in terms of percentage of its rated conditions at both constant and variable speed. It will be noted, for instance, that when the pump is operated at 60 per cent of its rated conditions, the power consumption at constant speed is 79 per cent of full rated horsepower. If, on the other hand, the pump is driven through a hydraulic coupling, it will run at 89 per cent of its rated speed and consume only 58 per cent of its rated power—a most attractive factor.

---

* Assistant to Vice President and Consulting Engineer.

[1] "Do Variable Speed Drives Pay on Centrifugal Boiler Feed Pumps?" by I. J. Karassik, *Power Generation*, September 1948, Worthington Corp. Reprint RP-381.

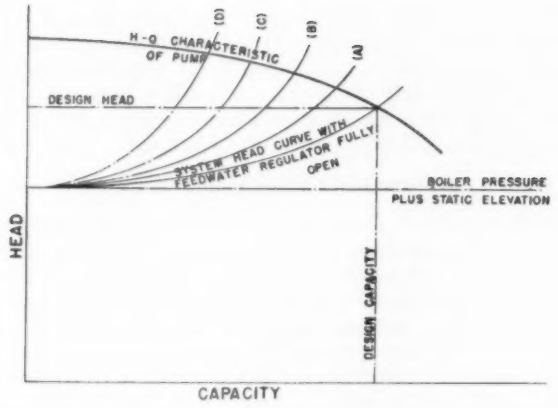

Fig. 1—The feedwater regulator must by throttling action absorb the difference between the pressure pump and the required boiler pressure

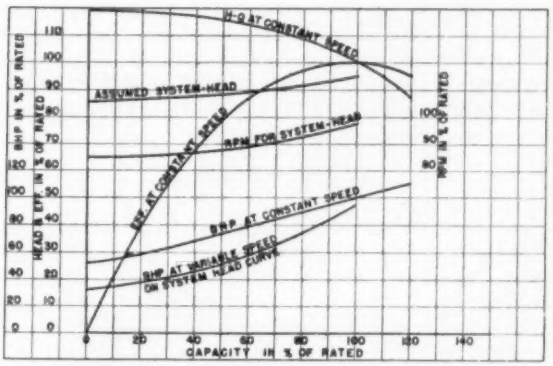
H-Q AT CONSTANT SPEED
ASSUMED SYSTEM-HEAD
RPM FOR SYSTEM-HEAD
EFF. AT CONSTANT SPEED
BHP AT CONSTANT SPEED
BHP AT VARIABLE SPEED ON SYSTEM HEAD CURVE
BHP IN % OF RATED
HEAD & EFF. IN % OF RATED
RPM IN % OF RATED
CAPACITY IN % OF RATED

Fig. 2—A typical variable speed centrifugal boiler feed pump establishes the above performance curves

Double as Feedwater Regulators?

Not all this difference, of course, is realizable as net savings, since the efficiency of the hydraulic coupling decreases with its speed in accordance with the following relation:

$$\text{HP input to hydraulic cplg.} = \text{Pump BHP} \times \frac{\text{Motor speed}}{\text{Pump speed}} + \frac{\text{Hydraulic cplg.}}{\text{Fixed Hp losses}}$$

In the particular case we have cited, the power input to the hydraulic coupling will be approximately 67 per cent compared to the 58 per cent pump brake horsepower at variable speed. Still, compared to the 79 per cent at constant speed, 12 per cent of rated power will be saved. It is these savings at various expected loads and for various estimated load durations which must be capitalized in order to evaluate whether the installation should include a variable speed hydraulic coupling.

Of course, there are certain additional intangible advantages, such as the elimination of feedwater regulator maintenance and longer pump life. Obviously, the life of a pump which always operates at that speed and develops that pressure which is required to feed the boiler and no more, will be improved over the life of a constant speed unit.

As we have stated, after a decision to use a hydraulic coupling has been made, there still remains the question whether to retain the feedwater regulator valve or whether the regulator valve can be entirely eliminated. If the valve is retained, the combination acts essentially as the two-valve arrangement of feedwater regulator and excess pressure regulator used to work. Here the valve remains under the control of the three-element regulating impulse, while the hydraulic coupling is used to vary pump speed so as to maintain a constant pressure drop across the valve at all loads.

Since the regulator valve loss may be in the order of 50 to 100 psi, its elimination will reduce power consumption by 2 to 4 per cent in the event the boiler feed pump develops in the neighborhood of 2500 psi net pressure. This saving is quite appreciable. Why not take advantage of it?

The Case for the Feedwater Regulator Valve

Operators who wish to retain a feedwater regulator valve in boiler feed installations where a hydraulic coupling is included use the following arguments in favor of their opinion:

(1) It is claimed that the combination of a regulating valve and pump speed control provides a quick response to the control signal which reduces the time lag in the hydraulic coupling.

(2) The regulating valve provides a means of eliminating the peculiarities in the hydraulic coupling operation. The curve showing output speed versus control device position is not strictly linear and fluctuations are occasionally detected in some hydraulic coupling installations.

(3) The presence of the regulating valve in the system provides the necessary excess pressure for desuperheating injection at all loads where spray desuperheating is required or for supplying sealing water to the circulating pumps on controlled circulation boilers if needed.

Sound as these arguments appear to be on the surface, it must be considered, after all, that a great number of installations exist today with no feedwater regulating valve used in addition to the variable speed controls. And since these installations operate successfully, are the arguments cited above fully valid?

The many installations without feedwater regulator valve report no particular problem with respect to speed control response. It is true that, in a few cases, the author has seen feedwater flow charts with a slight paint-brush effect rather than a straight line. While this indicates some minor fluctuations in speed and, hence, in flow (in the range of 2 to 3 per cent), we have

seen some constant speed installations show a similar effect. In any event, the drum level charts are perfectly smooth and cannot be differentiated from installations with feedwater regulator valves. Nor do these minor fluctuations appear to cause any ill effects. In most cases, proper adjustment of the automatic control will reduce or eliminate these fluctuations.

A Check-Up On Difficulties

One may speculate on the reasons which have led some operators to find that the elimination of the feedwater regulator valve leads to operating difficulties. One possible reason, of course, may well be experienced with a pump which has a pronounced "droop" in the low capacity range. If we examine the curves on Fig. 2, we will see that while the required speed varies very little in the low capacity range, neither the head-capacity nor the speed curves are unstable. In other words, the head-capacity curve rises constantly to shut-off and at no point does the speed curve reverse itself, so that a speed increase is indicated in order to obtain a capacity reduction.

On the other hand, were the head-capacity curve at constant speed extremely unstable, the required speed curve would have a definite reversal, as illustrated on Fig. 3, which shows in an exaggerated scale the effect we have discussed. As capacity is reduced from full load, the required speed of the pump decreases. But once the required capacity has fallen to a value of "A," any further reduction in capacity can only be achieved by means of *a speed increase*. Certainly, the control of such a pump may present some difficulties and it is because of some experience of that sort that an operator may take the unshakeable position that he wants to have a feedwater regulator as well.

Note that this type of curve is not too well suited for operation in either case. It is only that less difficulties will arise if the function of the hydraulic coupling is supplemented by a throttling device.

One argument which has sometimes been advanced is that a steeper pump head-capacity curve would be conducive to a less sensitive reaction on the part of the hydraulic coupling and its controls. This argument, however, fails to take into account the basic nature of head-capacity curves of pumps in the specific speed range encountered on boiler feed service. It is true that some leeway is available to the pump designer with respect to the percentage rise between the rated conditions and shut-off. For instance, the head-capacity curve on Fig. 2 shows a shut-off head of 119 per cent of rated head. Without affecting the pump efficiency too drastically, it would be possible to design a group of impellers such that this shut-off head would become 125 per cent of rated head, for instance. But the head-capacity curve would still be quite flat at light loads, the increase in percentage rise being mainly evident near the rated conditions. In other words, the curve would be steeper in the range between 100 and 50 per cent capacity. Thus, no particular benefit would be derived insofar as sensitivity of control at light loads is concerned.

A serious disadvantage, however, would result in the above instance from power consumption, since with a higher head at constant speed in the light load range, a greater speed reduction would be required and a greater power input would be required to the hydraulic coupling. Since pump speed must vary as the square root of the heads, power consumption with a 125 per cent shut-off head pump would exceed that with a 119 per cent curve by approximately 2.5 per cent. While in itself this additional loss is almost negligible, it certainly should be avoided if it yields no particular advantage.

Desuperheating Injection Pressure

The argument about the excess pressure provided by means of a regulator valve to facilitate desuperheating injection at all loads is based on sound facts. When the feedwater regulator valve is eliminated, the difference between the discharge pressure and the superheater pressure (which is at its maximum at full load) decreases constantly with the decrease in load, until a certain load is approached at which there is insufficient excess to provide the needed injection.

The load at which the pressure becomes insufficient to cause flow into the reheater attemperator depends to a great extent upon the point in the feedwater cycle from which the injection water is to be taken. Normally, several high pressure heaters are located downstream of the boiler feed pump. If the injection water is taken between the feed pump and these heaters, the friction losses through the heaters provide a higher pressure at the point of withdrawal than if the water is taken after the heaters. Thus, sufficient excess pressure is available down to a lower load in the former case than in the latter. The choice between the two arrangements will be influenced, however, by considerations of heat balance rather than of relative ease of desuperheating.

Withdrawing the feedwater required for desuperheating before it has passed through the high pressure closed heaters has an unfavorable effect on the plant heat rate, because less steam is bled from the high pressure steam turbine stages and condensed in the closed heaters. Therefore, if the amount to be withdrawn is a significant percentage of the total flow, the increase in heat rate may be appreciable and the tendency would be to take

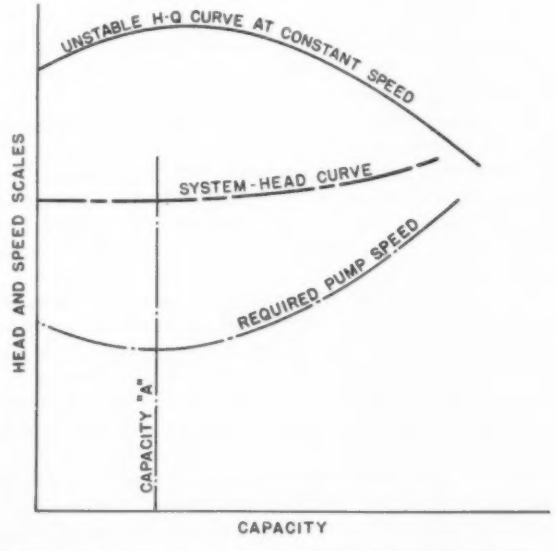

Fig. 3—The performance curves of a highly unstable variable speed pump presents H-Q characteristics as above and hence this pump control is difficult

the desuperheating feedwater after it has passed through the heaters. On the other hand, taking the water before the heaters may provide sufficient excess pressure down to all loads where desuperheating is required and permit eliminating the feedwater regulating valve altogether. Thus, close figuring may be required to determine which of the two effects on the heat rate (reduction in heater through-flow or increase in total head to be generated) is more significant in the overall heat balance.

If finally it is determined that elimination of the feedwater regulator valve does not permit proper operation of the desuperheating arrangement, a valve may have to be included. But in this case, a valve located in the discharge line does not serve the purpose of feedwater regulation, but rather that of providing a pressure differential over the superheater pressure. In other words, calculations are carried out to determine the minimum pressure difference which must be maintained at all loads and the valve is controlled to maintain this difference. For instance, if at extremely light loads the boiler feed pump pressure must exceed the superheater pressure by 50 psi, controls are arranged to provide this pressure drop by means of the valve. Actually, at high loads, the pressure differential exists for other causes and the valve is held in wide open position. It is reasonable to expect that under these conditions the pressure drop through the valve can be as low as 25 psi.

There is, however, a simpler solution which consists in providing a by-pass around the main boiler stop valve, and a motorized valve in this by-pass. As soon as the pressure margin becomes insufficient to inject desuperheating water, the flow to the boiler can be routed through this by-pass and an artificial drop maintained by means of the motorized valve.

This by-pass line can be made to perform an additional function during a start-up after the boiler has been shut down and the pressure in it reduced. While a hydraulic coupling can be operated at any desired pump speed from 0 to 100 per cent, there are certain reasons why some installations limit the total range of speed variation to a narrower band. In some cases this is intended to increase the sensitivity of the control. In other cases, some pump manufacturers do not wish to have the pumps operated below a certain speed. Thus, the scoop tube is intentionally limited in its travel. This provision, however, has caused difficulties in some cases because at start-up the pump was made to run at a speed in excess of that corresponding to the low starting pressure and the boiler would be accidentally flooded. The motorized valve in the by-pass line can be used to create a sufficient pressure drop so that the pump operates at a reasonable speed even under start-up conditions.

It should be apparent from this discussion that it is perfectly feasible to control a boiler feed pump installation embodying a hydraulic coupling without using a feedwater regulator valve. But remember that if the steam power plant designer prefers to include such a valve, the only penalty he pays is the excess in power consumption caused by the pressure drop through that valve and the initial cost of the valve itself.

Out of such an evaluation of the pros and cons for the hydraulic coupling as a feedwater regulator plus first hand experiences will come the answer to the dual role of the coupling.

pd

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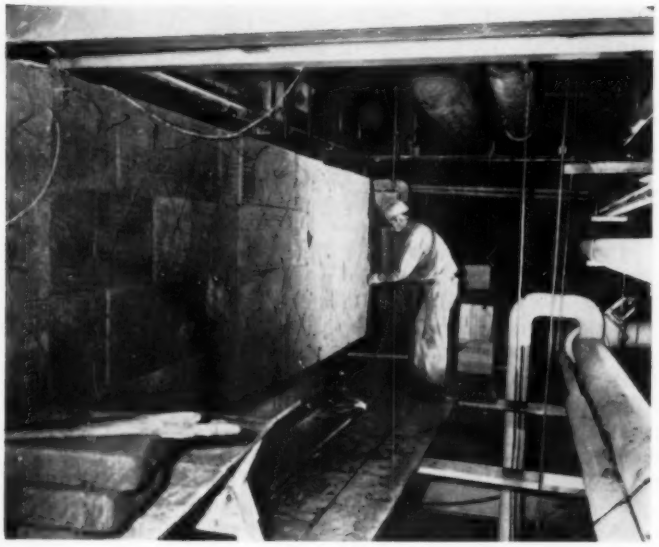


Fig. 1—Mono-Block was secured to ducts and housings at Taconite Harbor with No. 14 gage annealed iron tie wires. The wires are anchored to $^{7}/_{8}$-in. studs shop welded to the plate

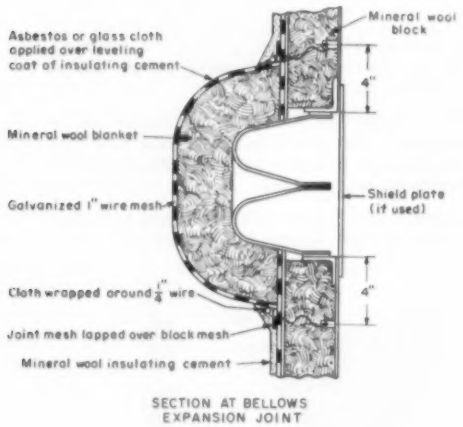
FOR maximum thermal efficiency, an insulating barrier must cover heated equipment completely. On regular, uninterrupted stationary surfaces this is a relatively simple problem with a straightforward solution. The insulating material, regularly shaped, is simply fastened mechanically to the hot surface in any approved manner, and that is that.

Surface irregularities complicate the problem somewhat because they call for an interruption in the basic insulating layer and some sort of special insulation treatment. Duct flanges and stiffeners are examples. They must be insulated, of course, because although their surface area may seem small in comparison to the overall duct area, it is significant when considered in terms of total heat loss potential. However, flanges and stiffeners, although requiring special treatment, are not especially difficult to insulate. They usually require only that the insulating material be built out around them for complete coverage.

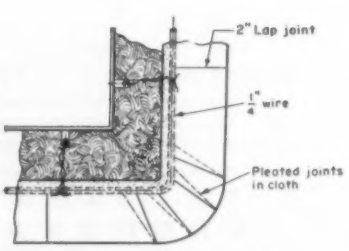
The duct expansion joint is another story. Here the successful application of insulation requires more than just the mere coverage of the joint area with a sufficient thickness of insulating material. The insulation must be secured in such a manner as to allow the joint to function properly—to move—without being damaged.

There are two fundamental approaches to insulating an expansion joint so that it will function properly with the insulation intact. One is to use a material which is sufficiently flexible to adjust itself to the movement of the joint. The other is to use rigid insulation constructed in two separate sections which permit relative movement. Materials and attachment methods will vary from job to job but most expansion joint treatments will conform to one of the above principles.

The amount of expansion a joint is expected to accommodate will influence the choice of method, as will the materals and techniques used to insulate the ducts themselves. Use of the same type of insulation and sim-


Asbestos or glass cloth applied over leveling coat of insulating cement
Mineral wool block
4"
Mineral wool blanket
Shield plate (if used)
Galvanized 1" wire mesh
Cloth wrapped around $\frac{1}{4}$" wire
4"
Joint mesh lapped over block mesh
Mineral wool insulating cement

SECTION AT BELLOWS EXPANSION JOINT



TOP VIEW OF CORNER THRU BELLOWS EXPANSION JOINT

Fig. 4 (a), above, pictures insulation over a bellows expansion joint in an air duct run. Fig. 4 (b), right, is a top view through a bellows expansion joint showing the method of securing cloth to a joint

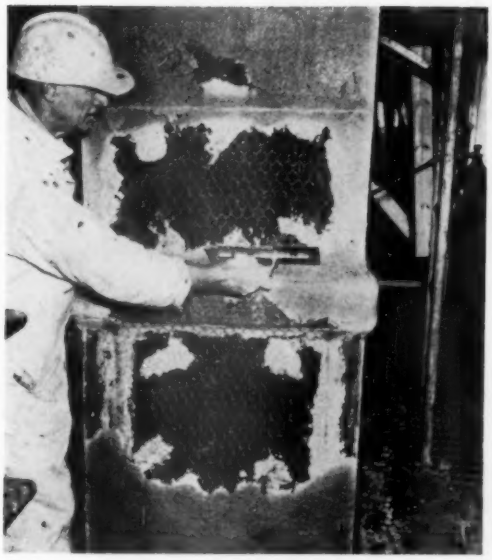


Fig. 2—No. 20 gage 1-in. wire mesh has been stretched over an insulated portion of the air duct to mills to serve as reinforcement for a $^1/_2$-in. layer of cement

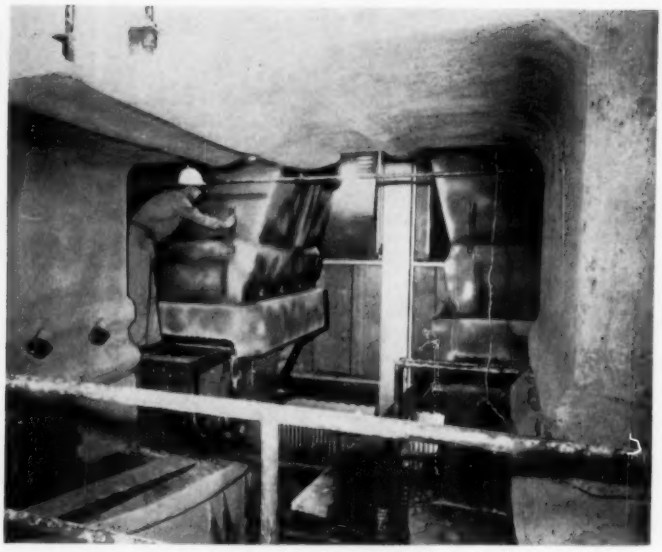


Fig. 3—View of gas inlet to preheater and the air outlet from the preheater (foreground) show how projections and expansion joints are neatly but completely insulated

ilar attachment methods as used to insulate the flat duct surface will generally simplify construction.

Both basic types of expansion joint insulation treatment were specified by the Combustion Engineering, Inc., in the insulation of ductwork associated with the two new 560,000 lb per hr boilers recently erected at Taconite Harbor, Minn., for the Erie Mining Co.

Mono-Block, a mineral wool insulating block manufactured by the Baldwin-Hill Co., Trenton, N. J., was used to cover the ducts and accessory housings. Lightweight and resilient, the material is easy to cut and shape to conform to surface irregularities and easy to apply. Methods of attaching the block are shown in the photographs. The finish consisted of Baldwin-Hill No. 1 Insulating Cement reinforced by wire mesh.

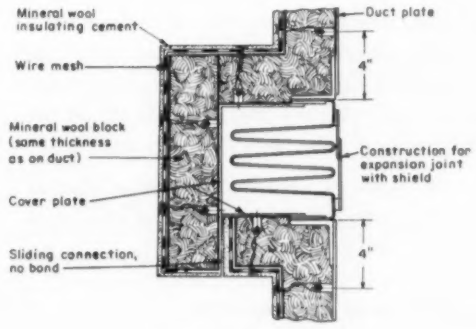
Flanges and stiffeners were insulated with built-up sections of block and by half-sections of molded mineral wool pipe insulation.

At expansion joints, use of the same basic attachment methods helped to standardize methods as much as possible. However, some additional materials were required.

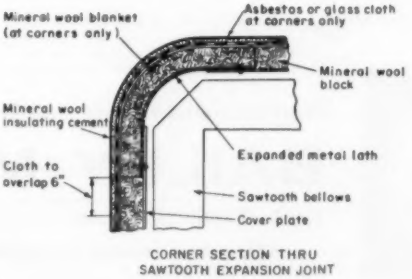
Duct expansion joints at Taconite Harbor were insulated with either rigid or flexible insulations depending upon their movement. For joints with relatively little movement—up to 3-in.—flexible insulation was used. For joints with greater expansion, the insulation was constructed of rigid material in two separate independent sections capable of moving with respect to each other. The two methods are shown in the drawings.

Designed for a 1000 F superheat temperature and operating at a design pressure of 1657 psi, each of the two large steam generating units will power a 67,500 kw turbogenerator. The plant will not only supply power for the mining company's port operations at Taconite Harbor, but for its mining and refining operations nearly 80 miles inland, as well.

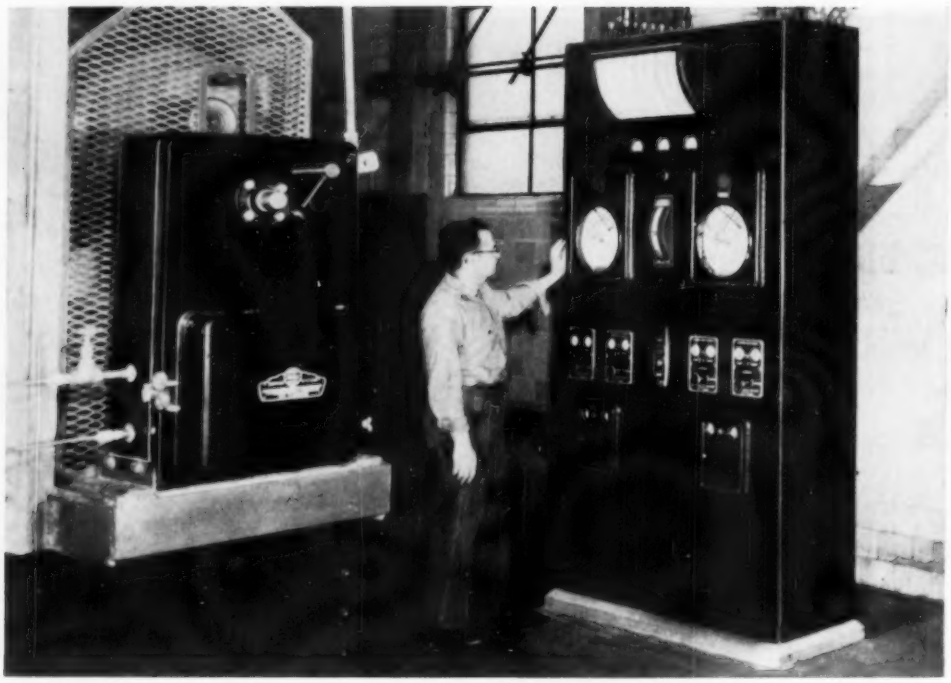
Insulation of facilities at the Taconite Harbor powerhouse was performed by Asbestos Products, Inc., St. Paul, Minn.



SECTION AT SAWTOOTH EXPANSION JOINT



CORNER SECTION THRU SAWTOOTH EXPANSION JOINT



This Bailey Control System helps cut fuel costs on a 70,000 lb per hr capacity 125 psi boiler in an industrial plant. Control drive in foreground regulates stoker.

How Bailey stretches your fuel dollar...

You can wring more energy out of a dollar's worth of fuel when you are getting optimum performance from your steam plant equipment. You get peak performance when Bailey Meters and Controls are on the job. They increase your plant efficiency.

Bailey is the choice of virtually all the most efficient plants on the Federal Power Commission's heat rate report. Here's why:

1. Complete Line of Equipment

You can be sure a Bailey Engineer will offer the right combination of equipment to fit your needs. Bailey manufactures a complete line of standard, compatible pneumatic and electric metering and control equipment that has proved itself. Thousands of successful installations involving problems in measurement, combustion, and automatic control are your assurance of the best possible system.

2. Experience

Bailey Engineers have been making steam plants work more efficiently for more than forty years. Veteran engineer and young engineer alike, the men who represent Bailey, are storehouses of knowledge on measurement and control. They are up-to-the-minute on the latest developments that can be applied to your problem.

3. Sales and Service Convenient to You

There's a Bailey District Office or Resident Engineer close to you. Check your phone book for expert engineering control on your steam plant control problems.

A132-1

BAILEY METERS

Instruments and controls for power and process

BAILEY METER COMPANY

1025 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

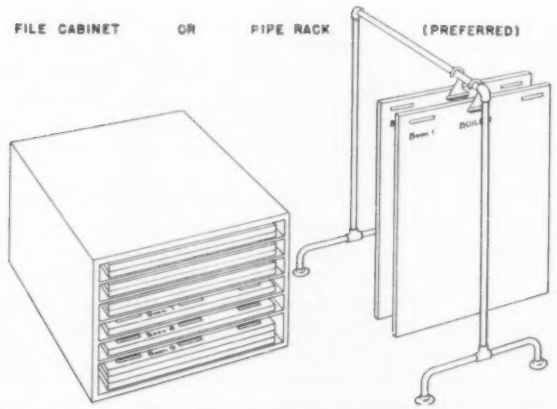


Fig. 1.2.1(b)—Individual blueprint books in (a) are stored in a set of file drawers or preferably hung on a rack

A system of ready reference to all important drawings, correspondence, purchase orders greatly expedites a power expansion project in the author's opinion. In this article he suggests the steps to establish such a system with appropriate illustrations.

By MILLS TOURTELLOTTE

Michigan Seamless Tube Co.

Good Organization Speeds Up Engineering Projects*

IN MAY of 1953, the Management of Inland Steel Company approved an appropriation to engineer and construct a modest power-expansion project, consisting mainly of a boiler, turbogenerator, and a substation. After management approval, the project was given a number by the accounting department, and was hereafter known as project 332. The main components that made up this project are shown in Table I. This figure is divided into two columns. The first column is the steam generator and its supporting utilities. The second column, turbogenerator and power-distributing facilities.

Stages of a Project

When a project is being engineered, there are a number of stages before the project is finally ready for production. They may be classified as research and development, cost studies, and execution.

Research and Development

During research and development, engineering must discover and develop a useful product or process. In this power project no particular research or development was necessary.

Cost Studies

During cost studies, engineering must develop the most economical method and place to produce this useful product in order to yield a profit. Considerable work was done to find the most economical method and location to establish this power project. There were three major alternates considered. They will be identified as (*a*), (*b*), and (*c*).

(*a*) Purchase power from the local public utility.

(*b*) Erect a new power station.

(*c*) Expand one of three existing power stations.

There were four major considerations under alternate (*c*).

(1) Gas-turbine-driven alternators.

(2) Topping steam-turbine-driven alternators.

(3) Condensing steam-turbine-driven alternators, using steam at higher pressures and temperatures than is now being generated.

(4) Condensing steam-turbine-driven alternators using steam at existing conditions.

The last of these considerations proved to be the most satisfactory.

* Presented before the ASME Fall Meeting, Hartford, Conn., Sept. 23–25, 1957 under the title, "Organize Your Engineering Project." Paper No. 57-F-11.

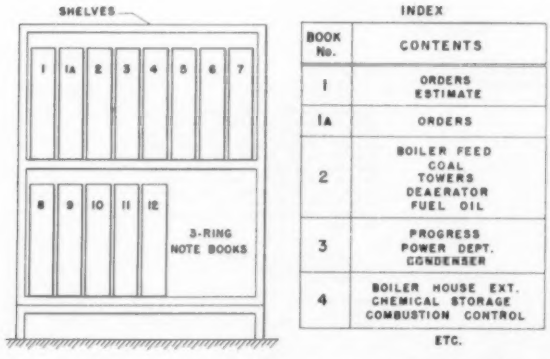


Fig. 1.1—Cabinet assembly for holding all project correspondence in one central point

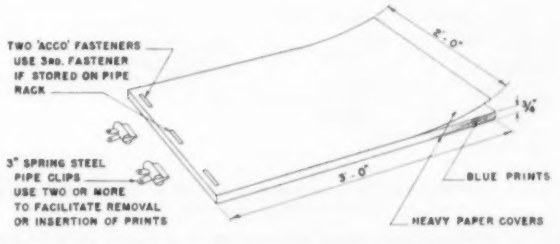

TWO 'ACCO' FASTENERS USE 3rd. FASTENER IF STORED ON PIPE RACK
3" SPRING STEEL PIPE CLIPS USE TWO OR MORE TO FACILITATE REMOVAL OR INSERTION OF PRINTS
2'-0"
3'-0"
BLUE PRINTS
HEAVY PAPER COVERS

Fig. 1.2.2—Blueprint distribution was recorded on a tally sheet such as above so their location was known at all times, see above

TABLE I—MAIN COMPONENTS, POWER PROSPECT 332

One 200,000 lb per hr, 300 psig, 700 F steam generator complete with automatic bombustion control

Fuels burned:
- Blast furnace gas
- Mixture blast furnace gas and natural gas
- Coke oven gas
- Fuel oil

One mile long 6-in. natural gas pipeline

One 400,000 lb per hr boiler feedwater heater

One 1150 gpm boiler feed pump

One chemical storage building

One 10,000 kw, 7200 v, 3 phase, 25 cycle condensing turbine generator

Two mile long transmission lines from generator to substation complete with three large transmission towers

One substation with 10 ton overhead crane, switchgear, 1000 kw M-G set, two 5000-kva transformers with automatic fire protection.

Execution

During the execution stage, engineering must execute one of the above cost study plans that management will choose as being the most profitable. It is this third phase of engineering, execution, which we dissuss here.

An important consideration to keep in mind throughout the execution of a project is that Management made the decision to appropriate a certain amount of money to produce this useful product because a profit would be made. The most profit will be realized when the project is installed as economically and as quickly as possible. If it becomes apparent, after the project is under way, that a major change in the project is necessary which will increase materially the project cost and/or materially increase the time the project will be put into production, such a change should be brought to the attention of management so that appropriate evaluations may be made.

It has been found that the best and quickest results are forthcoming when the cooperation of all interested parties is maintained. In this manner the experiences of specialists are incorporated into the project. The key to this cooperation is to keep these interested parties well informed of future plans and present progress. Those parties generally concerned with the project are: Management, purchasing department, operating department, construction department, engineering department.

Of these five divisions of organization, the operating department is probably the most significant, since it will be the operating department which will produce the product and maintain the equipment.

To effect this cooperation the division engineer appointed one man to coordinate the work of this project. It was the coordinator's responsibility to see that the project was engineered as quickly as possible with the cooperation of all concerned.

Together with a policy of cooperation, a coordinator, four to five capable designers, and the following elements of organization, the project was effectively executed.

A paragraph numbering system is used in the next section to promote logical thinking and quick reference. This numbering system is not new. A number of worthwhile publications listed in the footnote[1] use this system.

The elements of organization were divided into three main headings; maintain one central set of records, keep all concerned well informed, and distribute the work load.

The Elements of Organization

1.0 Maintain One Central Set of Records

Four divisions were established in the central records: correspondence, blueprints, purchase orders, and calculations.

1.1 CORRESPONDENCE

The main divisions in the correspondence file were of the major components in the project, namely, turbogenerator, boiler, boiler feed pump, and so on, as shown in Fig. 1.1. This figure shows the cabinet used to store the three-ring loose-leaf notebooks which contained the files. The index was placed on top of the cabinet for quick reference. You will notice that the index is divided into the major components of the project.

1.2 BLUEPRINTS

The blueprint file was composed of a number of individually bound books as shown in Fig. 1.2.1a. This figure shows a blueprint book containing prints of the turbogenerator. The spring clip is used to facilitate taking prints in and out of the file.

The blueprint file was separated into main divisions of

[1] J.I.C. (Joint Industry Conference) has a publication titled "Electrical and Hydraulic Standards for Industrial Equipment," October 1953. The American Standard Association has a publication titled "Installation of Gas Piping and Gas Appliances in Buildings," 1950.

Engineering Department

Blueprint Order for Prints to be Mailed by Print Room

To: Blueprint Supervisor - Project and Control Division

From: Tauchelletta / Stange (Senior Engineer) Date: 9-30-54

Job Description: #3AC Station - Loading Platform

1. It is requested that standard distribution of the following listed prints of drawings and Bills of Material be mailed as indicated by check mark in Paragraph 2 below:

90347 BM 1484 Sheet 323
90519

2. Distribution as Checked:

CHECK	NUMBER PRINTS	NUMBER B/M	NAME	DEPARTMENT
✓	10	10	A. L. Schroeder	Field Forces Dept. Plt. #[illegible]
✓	1	1	R. R. Myers	Mechanical Off., Plant #1
	1	1	W. A. Herman	Wire Shop Plt. #[illegible]
	5	5	H. R. Myers	Mech. Off., Plt. #[illegible]
	1	1	R. J. Beevy	Electrical
	2	2	H. M. Foreman	
	1	1	A. J. [illegible]	
	2			

Fig. 1.2.1(a)—Blueprint file consisted of a number of individually bound books made up as above

17-1960
PURCHASE ORDER
Item 1.3
Shipping Point
Net 30 days
June 30,1954
W. P. Nevins Co.
53 W. Jackson Blvd.
Chicago, Ill.
Stores
1 1
Control Arm for a 48" Heavy Duty - 125# Flanged - Butterfly Valve. Valve is shown on R.S. Products Dwg. B-10161, Inland Order BX-43030 on S.M. Smith Co. & W.P. Nevins. Control arm shall be similar to that shown in R-S Catalog #17, page 3, Fig. B-5148-A, for a single arm, complete with locking device bolts to fasten control arm to valve, key, and [illegible] in arm.
$56.00 ea.
All drawings are to be quadruplicate for [illegible] commencing comp[illegible]
Ten (10) of dimensio[illegible] shall
Figure 4 b
Item 2.54

Fig. 1.3—Purchase order forms were carried in a special file since the information they contain on material and services being purchased is most vital to a prospect's progress

the project, similar to the correspondence file (item 1.1), and appropriately stored as shown in Fig. 1.2.1b. This figure shows a set of file drawers and a pipe rack which were used to store the blueprint books. The pipe rack is preferred because no index is necessary, the titles on the books form their own index. The books do not jam on the pipe racks as they do in the drawers.

1.2.2. A record of blueprints sent to key people was established. The form used to make up this record has a double purpose. It requests the blueprints supervisor to send out blueprints to the appropriate personnel. When the form is returned to the originator it serves as a record that a portion of the project was completed on the date indicated. This form is shown in Fig. 1.2.2. The form is addressed to the blueprint supervisor from the engineers in charge of the job, requesting that blueprints of the tracings indicated be sent to certain personnel. The first column indicates to whom the prints are to be sent, the 2nd and 3rd columns indicate how many prints are to be sent, and the 4th and 5th columns show the address of each recipient of prints.

1.3 PURCHASE ORDERS

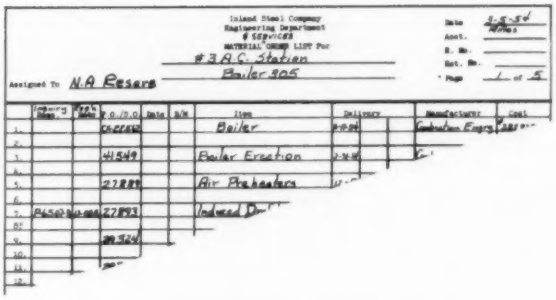
A file of purchase orders was established. Because the purchase order gives a detailed description of the material and services being purchased, it was perhaps one of the most frequently used files. A purchase order is shown in Fig. 1.3. Here it is seen from whom the material was purchased, the date it was ordered, the date we expect to receive the material, the cost of the material, a detailed description of the material, the account number, project 332, to which the material will be charged, and where the material will be used. The purchase order was filed numerically according to the purchase order number.

1.4 CALCULATIONS

Frequent use was made of authoritative technical literature. Calculations were recorded for a permanent record, and were filed in the correspondence file (item 1.1). A typical calculation sheet is shown in Fig. 1.4. This calculation sheet is divided into three sections: What is known, what is to be determined, and the solution to the problem.

2.0 *Keep All Concerned Well Informed*

Keep all concerned well informed is the second division in the elements of organization. Approximately ten methods were used to keep interested parties informed.


Inland Steel Company
Engineering Department
& Services
MATERIAL ORDER LIST For
#3 A.C. Station
Boiler 905
Assigned To N.A Resare
Date 2-5-54
Acct.
S. No.
Est. No.
Page 1 of 5

	Drawing Nos.	Prints Sent	P.O./S.O.	Date	R/R	Item	Delivery	Manufacturer	Cost
1.			CH-27592			Boiler	9-1-54	Combustion Engrg.	$887,000
2.									
3.			41549			Boiler Erection	2-1-54	C.	
4.									
5.			27899			Air Preheaters			
6.									
7.	P-452	Not sent	27893			Induced Dr			
8.									
9.			39324						
10.									
11.									
12.									

Fig. 2.2—Another means of keeping all advised was the list of materials and services ordered which was published monthly

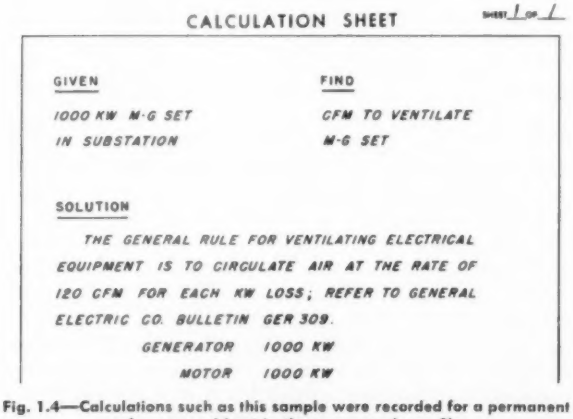
However, it was first necessary to maintain adequate records, as just explained (section 1.0), in order to have readily available information to report.

2.1 PROGRESS REPORT

The Progress Report was a device used to keep interested parties informed. Not only did this report convey the status of the project to the five departmental organizations mentioned previously, but it also kept all of us working on the project conscious for the need of making progress. Fig. 2.1 shows a typical progress report. The report shows from whom the report originated, the people to whom it was distributed, and the progress and key decisions that were made during the week. Here too, like the correspondence file (item 1.1), the reporting was made on the major components of the project.

2.2 LIST OF MATERIAL AND SERVICES

A list of materials and services *ordered* and *to be ordered*, published once a month, was another means of keeping people advised. Like the correspondence file, the list was divided into major components of the project. This list also served as the index to the purchase order file (item 1.3). Fig. 2.2 shows a typical list of material and services. This list is concerned with the component parts of the boiler. The significant columns are the purchase order number, the description of material or services, the delivery date, and the vendor. In the early stages of the project a purchase order number that was missing before the description usually meant that the material or service had not yet been ordered.


CALCULATION SHEET

SHEET 1 OF 1

GIVEN

1000 KW M-G SET
IN SUBSTATION

FIND

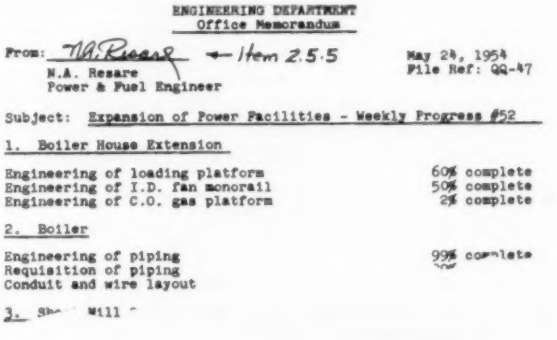
CFM TO VENTILATE
M-G SET

SOLUTION

THE GENERAL RULE FOR VENTILATING ELECTRICAL EQUIPMENT IS TO CIRCULATE AIR AT THE RATE OF 120 CFM FOR EACH KW LOSS; REFER TO GENERAL ELECTRIC CO. BULLETIN GER 309.

GENERATOR 1000 KW
MOTOR 1000 KW

Fig. 1.4—Calculations such as this sample were recorded for a permanent reference and kept in the correspondence file


ENGINEERING DEPARTMENT
Office Memorandum

From: N.A. Resare ← Item 2.5.5
N.A. Resare
Power & Fuel Engineer

May 24, 1954
File Ref: QQ-47

Subject: Expansion of Power Facilities - Weekly Progress #52

1. Boiler House Extension

Engineering of loading platform — 60% complete
Engineering of I.D. fan monorail — 50% complete
Engineering of C.O. gas platform — 2% complete

2. Boiler

Engineering of piping — 99% complete
Requisition of piping
Conduit and wire layout

3. Sh... Will ...

Fig. 2.1—The progress report was a device developed to keep interested parties fully informed

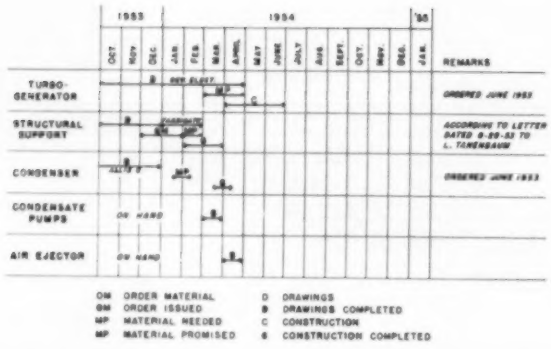


Fig. 2.3—Still a third source of project information was the schedule reproduction published periodically

Engineering Department
Office Memorandum

From: N Trbovich/mcf — Item 2.5.5 November 23, 1954
File: HR-44

N. Trbovich
Electrical Engineer

Subject: Plant 2 - Wide Flange Beam Mill Program - 15/60 Ton Crane - Requisition #17-2103 - Inland Order FX-61863, Account No. 4266-295-29 Obstructions Above Crane Rail, #1 Finishing and Shipping Building

Present during field inspection trip of #1 Finishing and Shipping Building, November 5, 1954:

C. Ireland W. H. Gray
J. Keene M. C. Tourtellotte

The new 15/60 ton crane is of greater capacity than those ... operate in #1 Finishing and Shipping ... allows approximately 2" ... column ...

Fig. 2.4—A record of important decisions made and agreed upon was made available to all interested parties

2.3 SCHEDULE OF MATERIAL AND SERVICES

A schedule of material and services, published periodically, was another device used to keep people informed. There is a certain sequence of moves that must be made in procuring material and services. First the material must be ordered, then the drawings to fabricate the material must be prepared, then the material must be fabricated and shipped to the erection site, and finally the material is erected and tested. Fig. 2.3 shows a graphic picture of this sequence. Along the ordinate is the turbogenerator and its major components. Along the abscissa is the months and year. The sequence of moves here were based on the fact that the condenser and structural support needed to be in place berore the turbogenerator was erected. Since the turbogenerator took the longest time to fabricate, the time for each move was plotted accordingly. The nomenclature for each move is listed. For example: a "D" between two arrow heads opposite the structural support from October 1953 through December 1953 is the time allowed for drawings to be made for the structural support. As the drawing work progresses, the "D" can be partially darkened. When all the drawings are complete the "D" will be completely darkened. Likewise the same procedure is applied to the other phases in the sequence. This chart shows that if each phase of the sequence is made accordingly, the turbogenerator may be erected immediately on the structural support when it arrives at the site.

2.4 MEETINGS

Frequent meetings with key personnel to discuss significant problems were another means of keeping people informed. A record of important issues discussed was distributed to those people who attended the meeting and other interested parties. Fig. 2.4 shows a typical memorandum of such a meeting. The memorandum shows from whom the report originated, the subject discussed, the people present at the meeting, the discussion, and to whom the memorandum was distributed.

2.5 OTHER MEANS OF KEEPING ALL CONCERNED WELL INFORMED

Other means of keeping all concerned well informed are listed as follows:

2.5.1 Reproductions were made (photostats, white or blueprints) of important incoming mail and distributed to those concerned.

2.5.2 Frequent use was made of the telephone, and significant information was confirmed in writing.

2.5.3 Carbon copies of important letters and memorandums were made and distributed to those concerned. Fig. 2.5.3 shows a typical carbon copy of a letter. This carbon copy shows that not only was Combustion Engineering and the Assistant Chief Engineer informed, but also the four people listed to receive carbon copies likewise were informed.

2.5.4 On most of the large pieces of equipment, the manufacturer was requested in the purchase order to submit drawings for approval. After approval the manufacturer was further requested to submit 10 copies of all pertinent drawings and instructions for erection and operation of the equipment being furnished. The drawings and instructions were distributed to key personnel together with a copy of the accompanying cover letter.

2.5.5 The initials of the division engineer usually appeared on all important information distributed to key personnel. Having the division engineer's initials on important information is not only a means of keeping the division engineer informed, but it is also a means of sharing the responsibilities.

3.0 *Distribute the Work Load*

Distribute the work load is the third division in the elements of organization. Quite often it is necessary to engage outside engineering services in order to meet the schedules. Inland has approximately 100 engineers and draftsmen working on various projects. However, there is only a small group of approximately five engineers called the Power and Fuel Division, who spend most of their time on power work. This small group formed the nucleus of this power project, and outside engineering services were employed to supplement the work of this group in the appropriate quantities to meet the schedule (item 2.3). For example, an extension to our existing boiler house and substation were necessary. Five of our own men designed the buildings. An outside engineering firm detailed the building steel. Because it was necessary to proceed with foundations immediately, two of our own men designed, detailed, and checked the boiler and building foundations. An outside engineering firm was engaged to do the piping around the boiler, the turbogenerator foundations steel structure, and transmission towers, while the setting, piping, and wiring of the turbogenerator, boiler feed pump, deaerator, transformer bank, substation crane, and switch-gear were done by our own personnel. For a short period Inland had approxi-

Combustion Engineering, Inc.
Combustion Engineering Bldg.
200 Madison Avenue
New York 16, New York

Attention: Mr. J. R. Fowler, Engr. Dept.

Subject: Plant 3 - A.C.Station #3 - Expansion of Power Facilities - Boiler #5 Inland Order CX-22582 - Combustion Contract #7553 - Inland File QQ-47

Gentlemen:

In regard to your marked dwg. D-859-202, that accompanied your letter to Mr. A. J. Snider, dated August 11, 1954, we have the following comments:

1. Should not the dimension 4-15/16" be 3-[illegible] If not, where does 4-15/16" or [illegible]

2. If 3-3/8" is the cr[illegible] the offset be 1/4"

Fig. 2.5.3.—Carbon copies of important letters and memorandums were distributed to all individuals concerned

mately eleven of its own people producing working drawings for this power project.

Discussion

Before proceeding with the results and conclusions of the presentation a discussion of a few of the points just presented is probably in order.

A Record Clerk

Although it is possible to maintain a set of records as just described (section 1.0) without a clerk, there are two good reasons why a record clerk would be desirable. They are:

(1) The engineers and draftsman will have more time for engineering and drafting if they do not have to spend time maintaining the records.

(2) A full-time clerk could spend time making more detailed and up to date records.

Disposition of Records

The proper disposition of the records has not been resolved completely. However, most of the blueprint files have been given to the operating department since the tracings from which the blueprints were made are filed in the regular engineering department archives. A file of manufacturers' equipment drawings is being established similar to that of the tracing archives. It would be appropriate if these manufacturers' drawings were microfilmed since the Inland Engineering Department has had a microfilm file for a number of years. The correspondence and purchase order file will be merged with the engineering department central file. This merger will materialize when a suitable method can be established on just how these two files should be merged.

Inland is continually developing its facilities and, correspondingly, its engineering department records. At present a copy, usually a white print, of all incoming mail is given to the engineer in charge of the project, and the original is placed in the engineering department central archives. If this procedure were reversed, the following benefits would be derived:

(1) When the engineer in charge of a project needs more copies of a particular piece of mail he would not have the inconvenience of digging into the central file to obtain the original.

(2) When the project is completed the engineer in charge would place his file, all nicely separated into the main divisions of the project, in the central engineering department archives, and the copies that were maintained in the central file during the engineering of the project could be destroyed.

This is a reasonable procedure since it is only natural that the engineer in charge should be the best judge of which mail is important enough for further distribution, and how the project files should be arranged.

Scale Models

Before this power project was complete it was realized that perhaps scale models of the turbogenerator, boiler, transmission towers, and substation could have been used to expedite many decisions. In addition, the scale models might have been used to eliminate some of the field changes and they probably would have indicated a better arrangement of equipment in a few instances. Scale models are not a new idea. However, their use as a regular design tool is relatively new. Some of the recent papers on scale model techniques are listed below.[2]

Results

The results achieved were the erection and operation of a $3^1/_2$ million dollar power expansion project, reasonably close to the schedule (item 2.3) as shown in Fig. 4(a). The chart shows the major components along the ordinate and the ordered, delivered, and operated dates along the abscissa. The column to the right is the difference between the first and the third columns. This difference is the length of time from the date the equipment was ordered to the date the equipment was operated. The actual time it took to place the equipment into operation is the top figure. The bottom figure is the time predicted on the schedule, Fig. 2.3., discussed previously. You

[2] "Scale Modeling—A Practical Engineering and Construction Tool," by J. A. Carroll, Proceedings of the American Power Conference, March 1954.
"New Tool for Power Plant Design—Three-D Scale Models," by R. J. Sherman, *Consulting Engineer*, December 1954.

ON MAY 7, 1953 MANAGEMENT APPROVED THE APPROPRIATION FOR ADDITIONAL POWER	ACTUAL DATES (TOP) SCHEDULED DATES (BOTTOM), FROM FIG. 2.3			
	DATE ORDERED	DATE DELIVERED	DATE OPERATED	TIME FROM ORDERED TO OPERATED
10,000 KW TURBO-GENERATOR	JUNE 1953	MAY 1954 MAY 1954	SEPT. 1954 JULY 1954	1 Yr. - 3 Mo. 1 Yr. - 1 Mo.
15,000 SQ. FT. SURFACE CONDENSER	JULY 1953	FEB. 1953 FEB. 1954	SEPT. 1954 JULY 1954	1 Yr. - 2 Mo. 1 Yr.
200,000 LB/HR BOILER	JUNE 1953	AUG. 1954 MAY 1954	NOV. 1954 SEPT. 1954	1 Yr. - 5 Mo. 1 Yr. - 3 Mo.
400,000 LB/HR DEAERATOR	AUG. 1953	JAN. 1954 FEB. 1954	JUNE 1954 APRIL 1954	10 Mo. 8 Mo.
1150 GPM BOILER FEED PUMP	AUG. 1953	DEC. 1954 MARCH 1954	JAN. 1955 APRIL 1954	1 Yr. - 5 Mo. 8 Mo.
ETC.				

Fig. 4(a)—Completion dates for the major elements of the project are tabulated to the right

DRAWINGS	MADE BY
160	INLAND STEEL CO. ENGINEERING DEPARTMENTS
250	THREE ENGINEERING FIRMS
290	MANUFACTURERS, FOR INLAND'S APPROVAL BEFORE EQUIPMENT FABRICATION COMMENCED. (REFER TO FIGURE 1.3)
700	TOTAL DRAWINGS ISSUED TO INLAND'S CONSTRUCTION AND OPERATING DEPARTMENTS

Fig. 4(b)—To predict engineering costs on future projects the total drawings required were counted and recorded

will notice that the difference between actual time and schedule time was about two months. Of course for the schedule to have been perfect, the difference between actual time and schedule time should have been zero.

In order to help predict the engineering costs on future projects, the number of drawings that were issued to the construction and operating departments for this power project were tabulated, as shown in Fig. 4(b). The sum of 160 drawings which Inland made, and the 250 drawings which three other engineering firms prepared, is a total of 410 drawings. These 410 drawings represents approximately 25 engineers and draftsmen working for one year, 8 hr per day, 5 days per week. Assuming that each man earned $6000 per year, 25 men would represent approximately $150,000 spent for engineering services, or about 4.3 per cent of $3^1/_2$ million dollars paid for engineering services. In addition to the drawings issued there was a stack of correspondence approximately 4 ft high that was issued to convey instructions to all concerned.

Conclusion

Most of the elements of organization and procedure here presented have been practiced by many engineers at Inland Steel Company for a great many years. Many of these elements also undoubtedly have been in practice with other companies. However, it is believed that if some consideration were given to the combination of elements here presented, your next project would be engineered more quickly and effectively.

Another View on Automatic Dust Collection

DEAR EDITOR:

On page 41 of the August issue of COMBUSTION there appears an article by Mr. C. E. Beaver of Research-Cottrell, Inc., titled "Automation—The Key To More Effective Dust Collection." This article logically points out the advantages of automatic electrostatic precipitator operation, but it leaves the general impression that the control manufactured by Mr. Beaver's organization is the only available one.

As a matter of fact there are a number of automatic precipitator control devices available. Most of these devices are based upon the principle of counting sparks.

It is a known fact that the greatest corona effect is obtained when the precipitator is in the sparking range. Thus the controls, operating on the principle of counting sparks, are preset to a definite sparking rate. When the rate of sparking increases, the control operates to lower the precipitator voltage.

Changes in the temperature and condition of the gases affect the sparking rate and sparking intensity. Controls which merely count the sparks have to be manually readjusted to the desired sparking rate when gas conditions change.

It is to be noted that this type of control does not make allowance for the size or intensity of the sparks. This is a most critical factor in determining when a voltage control should operate. Western Precipitation Corporation has developed a unique circuit which contains no vacuum tubes, no counters, no relays, nor moving parts of any kind. The circuit is a most modern transistorized type and operates on a "sensing" principle which integrates the number of sparks with their intensity. When changes in the condition of the gases or of the dust to be collected take place, this "Transistomatic" control automatically senses the changes and changes the power to the precipitator to give the maximum efficiency under the new condition without manual adjustment of any kind. Thus it not only evaluates the number of sparks, but the power value of all discharges is integrated to provide the proper control signal.

Sincerely,
JOHN H. SENGSTAKEN
Gen. Mg. New York Office
Western Precipitation Corp

ASME Annual Meeting Highlights

As we go to press the 1957 ASME Annual Meeting was just getting underway. The program featured as many papers as did last year's, about 300 in all, and required the facilities of both the Hotel Statler and the Hotel Sheraton-McAlpin for the week of December 1–6. In our January issue we shall report on Banquets and new officers along with abstracts of those papers held to be of interest to our readers and not covered in the following.

Thermodynamics and Theory

Throughout the Annual Meeting a number of papers of a more theoretical nature were presented under various Division sponsorships reflecting, possibly, the growing awareness that this segment of industrial activity needs considerable attention and talent.

T. W. Jackson and **F. A. Thomas,** Georgia Institute of Technology, discussed "Equipment for the Study of the Viscosity of Steam," and covered specifically the equipment built at the Georgia Institute of Technology for use in determining the viscosity of steam at temperatures between 212 and 1200 F and at pressures up to 5000 and possibly 10,000 psi. It also described the senior author's past experience in determining the viscosity of steam by the annular transpiration method which is the system utilized in the investigation. The present work is being undertaken for the ASME as a part of a general steam research program being conducted by its Technical Committee on Properties of Steam.

A schematic diagram of the annulus test section and the associated equipment used in the author's test experience was shown and described. In a typical test procedure the desired temperatures in the annulus, boiler, and superheater were established. Then the proper flow rate was established. When this was done thermocouple emf values were recorded, a condensate-collecting beaker was placed into position, and an x-ray radiograph of the manometer was taken. After a reasonable condensate sample had been collected, the collecting beaker was removed, covered, and weighed on an analytical balance. If the x-ray picture showed sharp menisci, the run was considered to be satisfactory. If the menisci were imperfect, the run was discarded.

In the investigation corrections for entrance and exit effects were not considered necessary, since the 1-in. long entrance and 1-in. long exit sections were each equal to 100 diameters on an equivalent round capillary. For a round capillary, an entrance section equal to from 8 to 30 diameters is usually considered sufficient to establish the desired laminar-flow velocity distribution. The influence of the pressure-tap holes on the flow was neglected. The area of the holes compared to a circumferential area on the annulus of length equal to a hole diameter is small. If all the possible errors are considered it was believed that the maximum error in the data was less than 7 per cent.

Experience has since indicated that the equipment used in 1949 had severe limitations. These were the limited boiler capacity and the method of measuring a small pressure drop at a high level of pressure. In utilizing the annulus viscosimeter for instance, a pressure difference of a few millimeters of mercury at 10,000 psi pressure must be measured accurately. While it is possible to utilize the x-ray technique described it would be preferable to have a system whereby the ΔP could be determined accurately and rapidly. Using the X-ray technique a ΔP cannot be set precisely and its value is not apparent until the X-ray film is developed and dried. Furthermore, the use of a boiler reservoir system as utilized previously is unsatisfactory for pressures near and above the critical pressure.

In view of the foregoing, the experimental equipment was designed to eliminate the boiler reservoir and X-ray technique of measuring pressure drop. The system constructed at Georgia Tech was shown schematically. In place of the boiler reservoir a variable-stroke pump, a surge chamber, a heated tank, and a high-pressure-drop nozzle have been installed. Data are currently being obtained on the equipment.

D. B. Bosley, R. S. Leddick, U. S. Navy, and **E. E. Drucker,** Syracuse University, undertook to explain "A Fundamental Approach to the Analysis of Steam Surge Tank Transients." The authors began with the observation that variations in the average temperature of the liquid in a closed loop, produce corresponding changes in the density and total volume of the liquid. If the system is completely filled with the liquid, it is subject to enormous pressure changes. In the design of nuclear-reactor power plants, for example, it is essential that a surge tank, partially filled with gas or vapor be installed in parallel with primary and intermediate coolant loops to limit overpressures to some tolerable level.

With few exceptions, the average coolant temperature and total coolant volume are directly proportional to reactor power. This produces, for a power increase, a positive or in-surge of coolant to the pressurizer vessel, which in turn induces overpressures in the vessel which are imposed on the entire primary coolant loop. If the power output remains at an elevated level, the surge-tank pressure decreases at a rate proportional to the heat flow from the compressed vapor in the tank. The desired normal operating pressure may be maintained by temperature control of the boiling water. In the case of power decrease and negative surge, pressure must be increased to normal by increased electrical heating. Although severe negative surges may reduce the pressure sufficiently to allow boiling to commence in the core, this condition is easily prevented by sharply stepping up the electrical input to the heaters. Of greater potential danger are overpressure transients induced by positive surges. Since the latter case represents a design

limitation, only the prediction of overpressure in the positive surge will be considered later. However, any related situation can be handled by an extension of the method the authors proposed.

To reduce the system to one capable of mathematical description and analysis, an idealized model was chosen and the following assumptions made:

(a) The surge tank is perfectly insulated.

(b) The mass of the vessel insulation, internals and water is considered a single lumped heat sink.

(c) The mass of vapor is constant.

(d) The process is thermodynamically reversible.

(e) Thermodynamic state changes occur under equilibrium conditions.

Assumption (a) is justified, since the vessel is actually very heavily insulated. Item (b) gives rise to the necessity for empirical determination of a heat-transfer parameter. It can be shown that the very small mass changes which can occur cause only negligible error in thermodynamic considerations, although they are very significant relative to heat transfer by condensation. Assumptions (c) and (d) are very closely approached due to the absence of mechanical friction and to the relatively slow rate of state changes. The rising water level may be thought of as a piston with plane surface, although this simplification is not necessary for the analysis.

The authors then developed a series of simultaneous equations whose solution for P(t) give the desired surge-tank behavior for any arbitrary driving function V(t) and hence answer assumption (e).

With thermal conductances established according to a set of experimental and simulated pressure-time curves, additional analog solutions are found for various values plotted. These curves summarize the results of the analysis, and although the experimental data has been used to partially determine the solutions, a moderate per cent error is evident when the curves are tested against the experimental runs. It appears, however, when examining certain specific runs, that the experimental data is in error. Behavior of this type is not to be expected in a compression process commencing with saturated steam. The average difference between pressure increases predicted and those experimentally observed is in the order of 5 per cent. On the basis of the initial pressure, the average error is less than 1 per cent which is of the same order of magnitude as pressure measurement error. In addition, the errors were in almost all cases conservative ones.

The ability to represent the results satisfactorily in terms of dimensionless variables suggests their applicability to tanks of different size but which are exactly or even approximately geometrically similar to the experimental one.

In their conclusions the authors felt that positive surges cause superheating of the surge-tank steam mass. During rapid surges, in addition, the walls and water in the tank are subcooled and condensation probably occurs. The change in mass of the steam, however, is very small. Over-pressures predicted by assuming isentropic compression are conservatively high. More realistic peak pressures may be estimated by sinusoidal surges in a vertical cylindrical surge tank of length/diameter ratio about 4. The method of analog simulation appears to be a satisfactory and flexible approach to the problem, and a considerable increase in the accuracy of the results could be obtained with better analog equipment and some simple controlled experiments. The possibility of analog solution of other transient thermodynamic problems involving nonideal gases is indicated.

The problems of "Apparatus for the Experimental Study of the Thermodynamic Properties of Water" were the subject of a paper by **H. H. Reamer, G. N. Richter, W. M. DeWitt** and **B. H. Sage,** California Institute of Technology. In this study the measurements of the Joule-Thomson coefficient, it was felt, would represent an extension of the earlier studies of Davis and of Kleinschmidt. Values of enthalpy were obtained by Havlicek and Miskovsky and heat capacities were reported by Knoblauch and Koch. These data were used by Keenan and Keyes as a part of the experimental background for an excellent tabulation of the thermodynamic properties of steam. Most of the experimental data were limited to temperatures below 850 F and to pressures below 5000 psi.

Recently there appeared in the Russian literature new measurements of the effect of temperature and pressure upon the enthalpy of water. This information was brought together into a rather extensive tabulation of the thermodynamic properties of steam. These derived values were somewhat at variance with the earlier tabulation of Keenan and Keyes. Recently a program of study was initiated on the enthalpy of steam at pressures up to about 15,000 psi in the temperature interval between 500 F and 1100 F.

In addition, the influence of pressure and temperature upon the specific volume of water is being studied at the University of Toronto and should supplement the recent work by Kennedy. These more recent measurements, coupled with the Joule-Thomson and enthalpy-pressure coefficients to be determined with the equipment described here, should suffice to establish the thermodynamic properties of water at temperatures up to 1500 F and for pressures as high as 15,000 psi.

The equipment the authors describe was designed to investigate both the Joule-Thomson coefficient and the isothermal enthalpy-pressure derivative. A limited number of measurements of the isobaric heat capacity may be attempted later in the program. The former studies will be carried out at a series of states, utilizing relatively small pressure differences which in all cases will be less than two atmospheres. In order to obtain Joule-Thomson data, the fluid will be circulated through a porus alumina thimble under conditions closely approximating constant enthalpy. Measurements of the change in temperature for a known change in pressure will be made. The second set of measurements will involve the evaluation of the rate of electrical energy addition necessary to keep the outlet temperature of the fluid the same as that at the inlet to the thimble, while steady flow occurs at a known rate. From the latter data the isothermal enthalpy-pressure coefficient can be obtained. Measurements of this coefficient will not be made at states for which it has a positive value. It should be emphasized that neither of the flow processes follows exactly an isenthalpic or isothermal path. It is necessary to take into account appropriate small corrections in order to obtain the desired thermodynamic properties from the measured quantities. By methods of analysis that are available these small corrections for

deviation from the desired path can be evaluated.

"The Acoustical Properties of Steam" were presented by **R. B. Lindsay** and **D. D. Edan,** Ultrasonics Lab. of the Department of Physics, Brown University. In their paper a method for studying the acoustical properties of steam at high pressures and temperatures was outlined. Specifically it covered the design and construction of a fixed-path acoustic interferometer with associated equipment for measuring the temperature dependence of ultrasonic velocity and the sound-attenuation coefficient as a function of temperature and pressure. This represents the initial stage of a program to study molecular relaxation in steam at pressures up to 1000 atm and temperatures up to 600 C. The equipment described, the authors claim, should function to 100 atm and 200 C.

S. Ling, Foster Wheeler Corp., introduced "A Note on Pseudotransition Locus for Water in the Supercritical Region." In the author's words "Supercritical steam generation suggests a continuous heating of a homogeneous fluid whose properties undergo a continuous transformation from a compressed liquid to a gaseous state in the subcritical steam generation." The demarcation between the two phases, as Mr. Ling points out, is, therefore, quite arbitrary and current discussion in literature on supercritical steam generation presents little emphasis or clarification on the definition of the precise location of the pseudotransition zone. This location has important bearing not only on certain design considerations but also control dynamics of the steam generator in question.

The author then employs two successive approximations which yield rational results from the critical point up to 7000 psia with the indication that the pseudotransition temperature is an increasing function of pressure. The results in the region of 7000–10,000 psia suggest irregularities.

A correlation of these points by least-square procedure indicates that pseudotransition temperature increases rapidly with pressure. The temperature appears to rise with a declining rate in the high--pressure end though it seems unlikely that the locus should show a maximum value. In view of the circumstances under which the values of specific volume in this region were derived, their accuracy and consistency contribute a plausible explanation of greater departure from the correlation drawn from the interim Steam Tables. Fortunately, the present status on advanced steam conditions in power generation suggests no immediate concern in the high-pressure end of the locus and a correlation excluding these irregular points may serve useful purposes at present.

The highly important "Interpolated Tables Enthalpy of Superheated Steam" were presented by **J. Madsen** and **W. J. Pfeifer, Jr.,** The Detroit Edison Co. To effect a saving of engineering man-hours, a comprehensive table of enthalpies of superheated steam has been compiled by interpolation of Keenan and Keyes' tables using a digital computer. This paper described the compilation and availability of this table.

The following criteria were set up: (a) The tables should contain the enthalpy values for increments of 1 F up to 1600 F, and 2 psia (1 psia under 100 psia) up to 2500 psia; (b) the tables should be accurate, all values agreeing with those given in the original Keenan and Keyes' tables; (c) data must come from the computer in a form suitable for final printing, since the volume of information would be too large to permit transcription and (d) the cost of the table preparation should be limited to that amount which could be recovered in man-hour savings in a reasonable length of time.

An analysis of the original tables indicated the following would be required to obtain the desired accuracy: (a) Second-order interpolation in the temperature direction from 1 psia to 950 psia; (b) third-order interpolation in the temperature direction from 1000 psia to 2500 psia; (c) linear interpolation in the pressure direction. Lagrange's interpolation formula was used for (a) and (b) and Newton's forward interpolation formula for (c). These formulas were given in an appendix to the paper

The tables consist of 2770 pages, one of which was shown. They were printed on 9 × 12-in. paper and bound in five volumes for ease of handling. The index of the five volumes was shown.

There are a few values in the 1400 to 1600 F range of the tables which appear to be computational errors. These are actually the result of the values in the original tables having been rounded off to five significant figures.

The interpolated tables have been deposited as Document Number 5280 with the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C. A copy may be secured by citing the document number and requesting quotation for photoprints or remitting $98.00 for 35-mm microfilm. Advance payment is required. Make checks or money orders payable to: Chief, Photoduplication Service, Library of Congress.

J. W. Murdock, Naval Boiler and Turbine Laboratory, and **J. Goldsbury,** General Electric Co., supplied as their paper, "Problems in Measuring Steam Flow at 1250 Psia and 950 F With Nozzles and Orifices." The measurement of steam flow at 1250 psia and 950 F with nozzles and orifices is discussed (a) during their calibration and (b) during performance tests on a turbine. All primary elements were constructed to ASME specifications, the nozzles being of long-radius, low-ratio design with throat taps, the orifices employing radius taps.

The calibrations for the flow nozzles indicated that reliable repeatable results could be obtained although one nozzle exhibited an abrupt increase in discharge coefficient of about 0.5 per cent at about 2 per cent pressure differential. The measured coefficients of discharge were within Power Test Code "probable tolerances" of ±1.25 per cent. The calibrations of the orifices were of little value because of permanent distortion of the orifice plates as a result of difference in expansion between the plates and their holding flanges.

For measuring steam flows to the turbine additional orifices were made up of different material, reducing distortion of the plates to the point of being negligible. The results of the turbine test with orifices and nozzles in series indicated excellent agreement between the flows based on orifice data using calculated coefficients and those determined from nozzle data using coefficients obtained from the calibration. Some trouble was experienced from deposits found around the nozzle throat taps.

While this paper presented data indicating excellent agreement of the two methods of flow measurement

during the turbine-performance tests, it also pointed out the need for more experimentation and knowledge of steam-flow measurement at elevated temperatures and pressures.

W. B. Harrison, W. C. Boteler and **S. C. Barnett,** Georgia Institute of Technology, combined talents on the paper "Thermal Diffusivity of Gases As Determined by the Cyclic Heat Transfer Method." In the development of the program for extending the data on physical properties of steam to high temperature and pressure, it was proposed that thermal diffusivities of steam should be determined by a cyclic heat transfer method. This paper described the theory and apparatus being employed to demonstrate the feasibility of the method with nitrogen and other gases.

Since the purpose of the present experiments were to establish the validity of the cyclic heat transfer method the demands on range of operation of the experimental system were very modest and nitrogen was chosen as a suitable medium for the first experiments since its properties are well known.

Only preliminary data are available at the present time and they are not sufficiently complete in scope to justify any conclusions or recommendations. For this reason the authors proposed that the data be reported completely at a latter date in Part II of this paper.

Plans for the experiments include the following studies:

(1) An examination to determine the effects of variation in frequency and temperature.

(2) A comparison of forced and natural circulation for the cooling water in the annular space around the test section.

(3) Additional experiments with helium, carbon dioxide, and argon, to expand the range of application of the method. The apparatus appears to be performing satisfactorily and the outlook seems very good for a successful demonstration of the cyclic heat transfer method for determining thermal diffusivity of gases and vapors.

The important "Review of Practical Thermometry" was offered as a paper by **R. P. Benedict,** Westinghouse Electric Corp. The purpose of the paper was (1) to sketch the growth of a satisfying temperature concept, passing quickly over the main stepping stones of thermometry; (2) to discuss briefly the ideas of thermal response and thermal recovery as they modify the steady-state, non-flow temperature concept; (3) to indicate in some detail various practical means for realizing temperatures, as defined by an internationally-accepted temperature scale; and (4) to admit to, and define, an uncertainty interval which most certainly is a part of each measurement. The paper is a valuable reference and as such is well worth obtaining in its complete form.

Metals and Materials

In order to obtain information on the corrosion resistance of superheater materials to steam under actual service conditions, six low- and medium-alloy materials were exposed at various temperature levels ranging from 950–1250 F for 7323 hr during the operation of an experimental superheater. This search for information was related in the paper "Oxidation of Superheater Materials by High-Temperature Steam," by **J. Hoke** and **F. Eberle,** Babcock & Wilcox Co.

The results of the exposure of the various materials indicate that there is a narrow temperature range over which oxidation begins to increase rapidly. This transition temperature is approximately 1050 F for carbon steel and 1100–1150 F for the low-alloy steels. The addition of up to 5 per cent chromium does not add materially to the long-time oxidation resistance of low-alloy steel, but a chromium content of 9 per cent markedly increases the temperature at which oxidation becomes serious.

The authors presented details of the steam-corrosion investigation and the results were compared with previous work. Rohrig, Van Duzer, and Fellows conducted corrosion tests in steam of 380 psi, at 925 F and 1100 F, at Detroit for 4000 to 16,000 hr. In comparing their 1100 F data with that of the present investigation, using corrosion penetration in mills per year as common denominator, it was found that their C-0.5-Mo steel had a corrosion penetration of 3.4 ipy and the 5Cr-0.5Mo steel, 3.5 ipy. This compared with 5 and 3.8 ipy for the corresponding steels included in this report. In other words, the agreement was quite satisfactory. The only other steel used in both investigations was plain carbon steel, and the latter displayed in the Detroit tests a considerably lower corrosion resistance.

Finally, air-oxidation data reported by United States Steel Corp. were included for comparative purposes. Since the corrosion behavior of the given steel is expressed as "weight gain," the results could not be compared directly with those of the present investigation. They agreed with the observations that the benefit derived from chromium additions of up to about 5 per cent is not very marked.

F. B. Snyder, T. A. McNarry and **F. Eberle,** The Babcock & Wilcox Co., presented a paper on "Investigation of Suitability of 18-8 (Type 304) Alloy for Superheater Service. . .With Respect to Corrosion and Stress-Corrosion Behavior in Chloride-Bearing Steam Condensate." The purpose was to determine the possibility of using nonstabilized 18Cr-8Ni-type alloys as high-temperature superheater materials in place of the present practice of using stabilized 18-8 materials. Comparative corrosion tests in synthetic steam condensates containing 38.4-ppm and 2000-ppm chloride have shown that the non-stabilized alloys, like the stabilized alloys, are not subject to intercrystalline corrosion attack in these media. Stress-corrosion tests in the same media showed that both stabilized and non-stabilized alloys suffered stress-corrosion cracking. No significant difference was observed in this respect between the two types of materials. In addition, nonstabilized 18-8 (Type 304) tubing, when installed in the pendant superheater of an operating stationary boiler, showed no intercrystalline corrosion attack after up to 54 months of service.

No stress-corrosion attack was observed on that part of the surface of the specimens which was in compression. The test results do not permit conclusions as to whether stresses below the yield point would also lead to cracking. In this connection it is pertinent to point out that the failures were not confined to the apex of the specimens where the tensions stresses were highest, but extended over the whole external surface. However they were more numerous or frequent in the most highly stressed, top region.

One of the most significant observations made in this investigation is the fact that failure was in almost all cases initiated by breaks or defects in the protective oxide coating produced by steaming at 1050 F. This was apparent after a few hours of testing from the formation of red dust at the affected locations. Since the specimens had been stressed after steam oxidation at 1050 F, doubts are in order as to whether breaks or defects in the oxide coating were produced by this operation at favorable sites such as at the interface of metal and carbides or nitrides. The direction of surface cracking was, in almost all cases, perpendicular to the applied stress. Stringer type of inclusions at the surface undoubtedly favored localized corrosion attack.

No significant effect of weld-metal composition—19Cr 9Ni.Cb versus 25CR 20Ni—or of welding per se was noticed; that is, failures were not more numerous in the vicinity of the welds where residual welding stresses might have prevailed. However, sharp surface contour changes and undercuts caused by the weld-bead deposition were noted to have acted as stress raisers, initiating crack formation.

J. F. Ewing, also The Babcock & Wilcox Co., then reported on "Croloy 15-15N. . .An Austenitic Heat-Resistant Alloy for Severe Tubular Applications at Elevated Temperatures." A combination of high costs for the super alloys developed for military jet aircraft plus a high resistance to the usual shop fabrication methods prompted the search for an austenitic heat-resistant alloy, primarily for tubular products, which possessed not only strengths superior to the present conventional tubular alloys (AISI Type 300 Alloy Series) but suitable working characteristics to permit manufacture of tubular products by conventional hot-working (rotary piercing, extrusion, rolling) and cold-working (drawing, sinking, tube-reducing) techniques.

Developmental work has been completed on a new austenitic heat-resistant tubular alloy possessing these two characteristics. This new alloy designated as Croloy 15-15N, was developed initially for tubing applications for high-temperature, high-pressure boiler equipment or other process equipment requiring strength properties in the temperature range 1200–1500 F in excess of those obtainable for the present AISI Type 300 Series of austenitic alloys.

This paper summarized extensive test work to evaluate the short-time tensile, creep-rupture, and creep properties of Croloy 15-15N together with structural stability as measured by impact tests after prolonged aging at elevated temperatures. Service experience with Croloy 15-15N was also described.

A. I. Smith, E. A. Jenkinson, D. J. Armstrong, and **M. F. Day,** High Temperature Mechanical Properties Section, National Physical Laboratory, Teddington, England, were the authors of a paper originally presented by the Institute of Mechanical Engineers entitled "Creep, Stress-Relaxation, and Metallurgical Properties of Steels for Steam Power Plant Operating With Steam Temperatures Above 950 F (510 C)."

The need for more detailed and longer-time information on the high-temperature creep and metallurgical properties of the more-advanced types of steel now being used in a large steam-power plant led to the investigations described in this paper. The relaxation properties of three bolt steels have been determined and, while the molybdenum-vanadium and chromium-molybdenum-vanadium types may just be adequate for a plant using 1050 F (565 C), the authors felt, it is clear that any advance in steam temperatures would require the adoption of new bolt steels. Long-time creep and rupture tests on molybdenum-vanadium pipe steel have revealed its relatively high creep resistance but the steel has a tendency to rupture with moderately low ductility and intercrystalline fractures. Similar tests on tube and pipe steels of the $2^1/_4$ per cent chromium-molybdenum type showed that this steel had somewhat lower creep resistance but the fractures were transcrystalline and the rupture ductility was higher than for the molybdenum-vanadium steel. The molybdenum-vanadium steel was structurally very stable, whereas depletion of the matrix of molybdenum was revealed in the $2^1/_4$ per cent chromium-molybdenum steel, a feature which may have contributed to its higher rupture ductility. Long-time creep and rupture tests on austenitic 18-12-1, chromium-nickel-niobium, pipe and tube steels have shown the high creep resistance of this material, although it may not be possible to take full advantage of this because of a tendency to rupture with low ductility at high stresses and temperatures; a direction of useful improvement is indicated. The long-time creep properties of a molybdenum-vanadium cast steel have shown this steel offers a useful improvement over cast $^1/_2$ per cent molybdenum steel, although the former had creep resistance considerably lower than that of the pipe steel of the same nominal alloy content. The above results convinced the authors that for steam temperatures in excess of 1050 F (565 C), cast steels will be required having superior creep properties to those of the molybdenum-vanadium casting; for this reason, several more advanced cast steels are already under test.

In a second paper originated with the Institution of Mechanical Engineers, **W. H. Bailey,** William Jessop & Sons, Ltd., England, **M. G. Gemmill,** United Steel Companies Ltd., England, **H. W. Kirkby,** Brown-Firth Research Laboratories, England, **J. D. Murray,** United Steel Companies Ltd., England, **E. A. Jenkinson,** National Physical Laboratory, England, and **A. I. Smith,** Mechanical Engrg. Research Laboratory, England, combined forces to report on "Creep Properties of Austenitic Nickel: Chromium Steels Containing Niobium."

The data relate to sixteen heats of steel, three of which are the heats described in the Smith, et al paper above, and are included for the sake of completeness. On a rupture basis, the tests extend up to 8000 hr at 550 C (1022 F), 42,000 hr at 600 C (1112 F), 41,000 hr at 650 C (1202 F), 26,000 hr at 700 C (1292 F), and 20,000 hr at 750 C (1382 F): on the basis of 1 per cent plastic strain the data extend up to 32,000 hr at 600 C (1112 F), 30,000 hr at 650 C (1202 F), 12,000 hr at 700 C (1292 F), and 14,000 hr at 750 C (1382 F). A few of the tests were simple rupture tests without measurement of strain, but in the majority comprehensive strain measurements were made. It has been thought sufficient to present only the data relating to rupture and 1 per cent plastic strain, the latter being the most useful single figure for giving an impression of the creep resistance of the material.

The tests with the exception of those of the tube and pipe steels already referred to, were made by the manufacturers and relate to wrought bars of small diameter ($^5/_8$–1 in.) and to a rotor forging. The range of temper-

ature and stress varied according to the applications in mind when the tests were undertaken, so that there is no uniformity of testing conditions. Since some of the tests have lasted nearly five years, the results describe the properties of steels that were made six or seven years ago.

The authors stress it was not the purpose of this paper to recommend a basis for the determination of service stresses. However, for steam-pipe service some recommendations that have been made involve the following criteria:

(1) 60 per cent of the average stress for rupture in 100,000 hr.

(2) 80 per cent of the least stress for rupture in 100,000 hr.

(3) 100 per cent of the stress for 1 per cent plastic strain in 100,000 hr.

The stresses that would be reached on these bases were given in table form, together with the design stresses suggested for steels of this type is the ASME Boiler Code. The table yields a very consistent impression of the levels of stress that can be safely employed at each temperature. It should, however, be pointed out that the higher stresses based on 1 per cent plastic strain can be used only if the steel is one in which an extension of 1 per cent during service can be contemplated. If the rupture elongation under the conditions of service is as low as 2 or 3 per cent, the design stress must be reduced appropriately.

Water Treatment

A number of papers on the general subject of water treatment or the problems arising from water soluble matter or steam carryover difficulties were sponsored by several divisions. They have been grouped together under the one heading above for convenience.

The opening paper sponsored by the Joint Research Committee on Boiler Feedwater Studies was "Ferrous Hydroxide-Solubility, Thermal Decomposition and Role in the Corrosion of Iron" by **P. D. Miller, J. J. Ward, O. M. Stewart** and **R. S. Peoples,** Battelle Memorial Institute. In recent years, the operators of steam-electric generating stations have experienced a serious problem of corrosion in the feedwater and steam circuits of boilers and turbines. The manifestation of corrosion is the deposition of iron oxide in critical parts of the system. One major difficulty has been deposition on the stop and control valves of turbines to an extent that the valves become inoperable. Deposits also occur in pumps and heaters. The cost of these difficulties to the industry has been great because of the necessity to replace damaged equipment, but perhaps even greater because of the necessity to reduce the load or to take equipment out of service. The cost of the latter has become particularly high as the size of the boilers and turbines has been increased. The work described here includes measurements of the rate of decomposition of ferrous hydroxide in water essentially free of foreign ions at various values of pH and temperature as well as measurements of the solubility of purified-washed material.

It has been concluded that the reaction mechanism of iron with water, in the range 250 to 550 F is not one in which the controlling reaction can be expressed by the Schikorr equation. It is believed that the formation of magnetite takes place at least in part by this reaction.

A somewhat different interpretation of the situation was presented by Douglas and Zyzes who indicated that the corrosion rate of steel at 450 F and below is linear with time.

Since the results of the present research have shown that the corrosion of iron above 250 F is not a reaction-controlled process, the process is apparently diffusion controlled in a manner described by the authors.

J. Angelo, and **K. C. Cotton,** General Electric Co., reported on the "Observed Effects of Deposits on Steam Turbine Efficiency." These deposits, especially those on steam-turbine nozzles and buckets, have been the subject of numerous articles and technical papers in the past. About a decade ago authors of these papers reported deterioration of turbine efficiency in the range of 10 per cent due to a thick coating of deposit on turbine nozzles and buckets. Since then progress has been made in boiler design, boiler chemistry and plant operation, all of which have reduced considerably the amount of deposit in steam turbines. This progress is even more remarkable, considering the fact that higher initial pressures have increased the ratio of steam to water density making it more difficult to eliminate carryover from the boiler. However, the incentive for further progress becomes greater an unit ratings and fuel costs increase.

Most large turbines installed during recent years on utility systems are of the reheat type. These reheat turbines have their high-pressure and intermediate-pressure sections operating totally in the superheat regions and provide the opportunity of measuring directly these section efficiencies by the enthalpy-drop method. This comparatively simple and direct test, which has been used in the past for the purpose of measuring the overall efficiency of noncondensing turbines, provides an excellent means for determining variations of turbine-section. This paper presents the results of recent tests conducted jointly by electric utility companies and the authors. company to show the magnitude of the deposit problem as it exists today and to describe in detail the testing techniques used.

The data on eight turbines, all of which used solid boiler-feedwater treatment at one time or other, indicate the following: Units with initial pressures of 1450 psig experience little loss of efficiency due to deposits in the steam path; at initial pressures of 1800 to 2400 psig, there is about 3 per cent loss in high-pressure-section efficiencies, and about 1.5 per cent loss in intermediate-pressure-section efficiencies due to deposits. The resulting loss in overall heat rate is 1 per cent which is worth $34,000 per year on a 200,000-kw machine, based on 80 per cent load factor and 30-cent fuel. The total value to the electric-utility industry of deposit-free turbine-generator operation based on 600,000,000 kwhr generated in 1956 and using the 1 per cent figure above would be about $20,000,000 per year.

These results indicate that about half of the 1.8 per cent gain in heat rate for increasing initial pressure from 1450 psig to 1800 psig may be lost due to deposits in the steam path. Turbines must be essentially as deposit-free at 1800 psig as they appear to be at 1450 psig if the potential fuel saving for the higher pressure is to be realized.

Usually, when the turbines are cleaned thoroughly, either by washing or by mechanical cleaning during an outage, the initial efficiency level is substantially regained, indicating the deterioration is due to deposits.

Atomic Industrial Forum of 1957

Roughly 1200 registrants took part in the 1957 Atomic Industrial Forum, the fourth such event, held this year at the Plaza Hotel in New York City, October 28–31. A concurrent Atom Fair was held at the New York Coliseum, October 31. The American Nuclear Society was holding its second Winter Meeting at the Henry Hudson Hotel, also in New York City, over this same period.

There were over 100 papers presented and more than 200 papers for the Nuclear Society people in addition to a luncheon plus a joint participation in the main banquet of the Forum. Below we report on only a few of the many papers available.

Appraisal of the Atomic Industry

Frederick Warren of the Pickard-Warren-Lowe Associates in a paper "Capital Equipment Requirements" presented highlights from a report just being completed for the Atomic Industrial Forum. The report was to deal with two major aspects, capital equipment and fuel cycle functions.

On the subject of capital equipment Mr. Warren displayed a chart which showed that a continued effort comparable to that now planned could result in an economic plant in 1964, at the earliest, less optimistic assumptions would produce such a plant in 1968. The maximum range produces 6,000,000 nuclear electrical kilowatts operating by 1968 while the minimum figures reach about one-third that volume. These represent about 2.1 per cent and 0.7 per cent respectively of total U. S. electrical capacity at that date.

Capital outlay based on an average of current cost estimates of the major power reactors including PWR and the four privately sponsored plants (Commonwealth, Con Edison, Yankee and PRDC) with indirect costs and interest during construction included is about $430 per E kw. The estimated maximum and minimum range of capital costs for the average large plant of 1968 was set at $360 and $280 respectively per E kw. The ways that these cost reductions will be established is considered at length in the report. The Euratom area offers a potential business interest to Americans and out of the experience this major construction program will afford certain economies should develop.

William Lowe, also of Pickard-Warren-Lowe Associates, followed with a paper on Fuel Requirements. Much of the paper was devoted to fuel costs with a table presented showing typical nuclear fuel costs for a large water type reactor in the U. S. using UO_2 slightly enriched and an operating date of 1960. The costs ranged from a maximum of 8.4 mills per kwhr to a 5.6 mills per kwhr minimum.

Leo Macklin, Combustion Engineering, Inc., followed with a Commentary on Capital Equipment Requirements. His opening remarks cited the wide variance in current cost estimates for the major power reactors now building as against the early estimates plus a reference to data on the cost variation between the lowest acceptable bid and the high bid for certain important components of the Engineering Test Reactor. The point was the serious concern of manufacturer and buyer alike—finding oneself committed to programs involving substantially greater expenditures than ever anticipated. The immediate future as Mr. Macklin sees it calls for heavy research and development outlays as an important part of the reactor work.

U. S. Power Reactor Experience

J. M. Yadon, Westinghouse Electric Corp., in his paper "Nuclear Power Plant Experience" likened his topic to one on the aviation industry in 1910. He, accordingly, confined his comments to the experience with the S1W plant, a pressurized, water-cooled, water-moderated plant used as a test facility to commercial practice and placed in operation in the Spring of 1953. It has been refueled once. During the past eighteen months this plant has been cooled down and started up over 60 times for crew training or to install test equipment.

Out of this experience Mr. Yadon expresses the conviction that a reactor can be controlled, that a pressurized water reactor is stable, that the type of control schemes, the effect of radiation, the type of operating personnel can be reviewed and less concern be exercised over safety. The same caliber personnel operating today's power plants can successfully operate nuclear plants. The more highly trained operators, moreover, can make valuable contributions at this stage to plant design and to an analysis of plant performance.

"The Army Package Power Reactor" was then described by **Kenneth Kasschau,** Alco Products, Inc. This unit, known as the APPR-1, has been operating for nearly six months and as yet the author feels that the only certain knowledge they have obtained is that they are a long way from having learned all there is to learn. As a case in point Mr. Kasschau cited his company's costly design and development work centering around the central rod drive. From this investment the major return has been a confidence on the part of the designers that the data were accurate and that stainless steel parts will operate under water as the only lubricant and coolant.

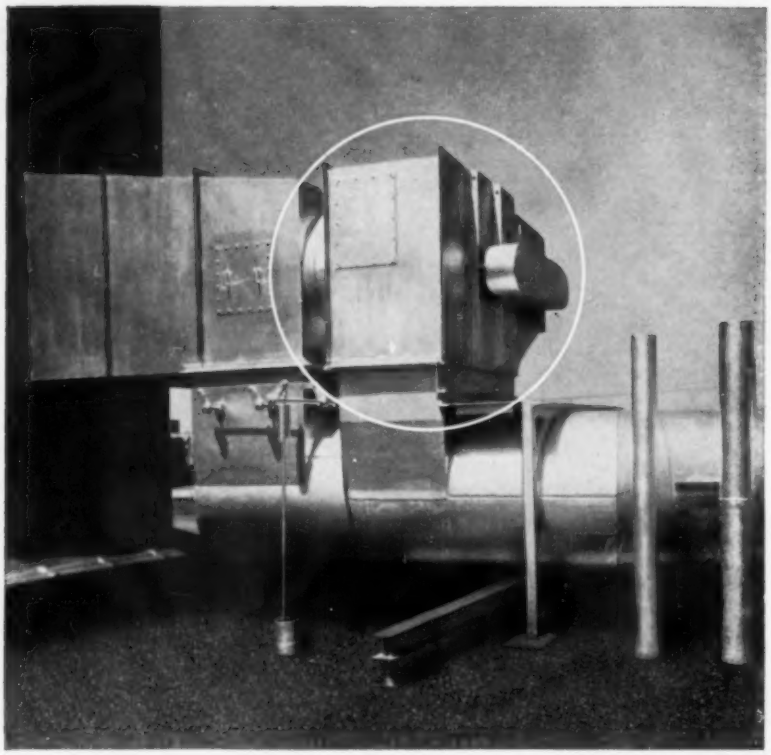
The erection and fabrication stages did furnish some very helpful information. For example the vapor container shell was erected and fully tested before any equipment was installed within it. This meant hoisting pieces 60 ft in the air and lowering them into position through a hatch. The author believes future units need not undergo this unconventional procedure. In the case of the fabrication stage the requirements for cleanliness were most urgent and of top importance so that in the future extreme care will be exercised over this need.

J. W. Harrer, Argonne National Laboratory, spoke on the "Experimental Boiling Water Reactor." This unit has been in operation for 10 months, has logged for over 50 per cent of its running time at less than full power.

About 48 hr are required to cool down the reactor pressure vessel before the head can be removed. This was done for the first time after startup in July of 1957. One fuel element was removed out of curiosity. Roughly 1 mg per sq in. of a reddish brown deposit less than 1.5 microns in diameter was found. It could be easily wiped off and upon test was found to be primarily iron, nickel, and aluminum oxide, which represent the bulk of the materials in contact with the working fluid.

"The Sodium Reactor Experiment" was the next subject for discussion and this phase was handled by **Frank Faris,** Atomics International. Two trial power runs were made in July to demonstrate feasibility and to gain information which would aid in the approach to full power. During both runs the inlet sodium temperature to the reactor was about 480 F and during peak power production of the first run the temperature difference across the core was 130 F. The plant, however, performed very satisfactorily and the reactor was quite stable.

The two most important maintenance jobs have been the removal of a damaged fuel element from the core and replacement of the disposable cold-trap cartridge. It has been relatively easy to maintain the oxygen



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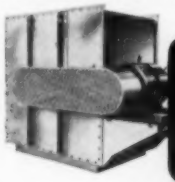

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content of the sodium at under 10 ppm with the cold traps. The addition of flow programming devices in the sodium systems and a pump to reduce leakage between the plenum feeding the fuel channels and that feeding the spaces between moderator cans has been found to be desirable.

Charles Trilling, Atomics International, followed with a report on the "Organic Moderated Reactor Experiment." This unit went critical only six or so weeks ago and hence all the data at the moment are on the preoperational phase. It is not a prototype of a nuclear reactor plant but rather a full scale irradiation facility designed to study the behavior of the most promising organic compounds under conditions similar to those encountered in power reactor applications. Kerosene was selected for all hydrostatic tests to avoid the dangers of water and also the freezing difficulties at room temperatures of the terphenyls which will be used as the coolant moderator in the final operation. Later the same series of tests were run with terphenyl. The author reported good results.

Samuel Untermeyer, II, General Electric Co., closed out the session with his paper "Vallecitos Developmental Boiling Water Reactor," which had gone to full authorized power—20,000 kw thermal and 5000 kw electrical, Thursday, October 24.

During the course of these power operation experiments, the BWR system was found to be extremely stable against load fluctuations and dynamic effects. The reactor easily generated its maximum licensed output and fuel temperatures indicated a large heat transfer margin. We now believe that this plant is capable of producing substantially more than the 20,000 thermal kw presently authorized. Measurements of radioactivity throughout reactor and turbine plant were most reassuring, and because of the very low activity level, direct maintenance of the turbine was possible during operation. In fact, Thursday, October 24, guests and members of the press were allowed to walk through the containment vessel while the reactor was operating.

Power Reactor Program in Review

A fourteen paper session on the Power Reactor Program was one of the major features of the Forum. **L. W. Fromm,** Argonne National Laboratory, discussed the "Argonne Boiling Reactor (ARBOR) Facility Status Report." He felt it necessary to review both the facts which have been learned from the operation of boiling water reactors to date, and the fields in which development work has not

yet begun. The BORAX reactors at atmospheric pressure and 300 psig, and EBWR at 600 psig, have shown that in steady state runs, increased system pressure definitely increases the power density and steam volume fraction which can be reached before instability is encountered. Other variables also show significant influence on reactor stability and the power density attainable before instability starts, but present information is qualitative only. Such variables include the amount of reactivity held in steam voids, the void coefficient of reactivity, flux distribution, and external system effects. The basic difficulty is that the quantitative effect of individual variables and their relationships have not been obtained.

The ARBOR facility will also permit quantitative investigation along these lines:

1—Forced Circulation. There are strong indications that forced circulation of the reactor coolant through the core, as opposed to natural circulation, would have a highly beneficial effect on stability, since in this case the void fraction is no longer a direct function of steam generation rate. Here the degree of subcooling and velocity of the water entering the core are important parameters.

2—Various Cycles. There have been three cycles proposed for boiling water systems, the direct, dual, and indirect. In the direct cycle (as in EBWR), all of the energy of the reactor is removed in the form of steam which is passed directly to the turbine to provide motive power for the generator. The exhaust steam is condensed and returned to the reactor by means of a feedwater pump. In the dual cycle only a portion of the energy required to drive the generator is extracted as in the direct cycle. Heat is also removed from forced circulation water in an external steam boiler which supplies a lower pressure turbine to provide the remaining driving power for the generator. In the indirect cycle, steam is passed from the reactor through a boiler where secondary steam is generated to supply the turbine.

3—Methods of Control. Many proposals have been made as to system variables which might be utilized as primary control parameters to effect reactor regulation in response to load changes. Among these are bypass steam flow and reactor pressure (as used in EBWR), feedwater flow, reactor water level, and forced circulation inlet temperature and flow.

4—Operational Safety. Before a boiling reactor can be properly sized, a determination will have to be made of how close to instability a reactor may safely be operated. Closely allied to this is an investigation of the signs which may be observed in the reactor to indicate the onset of instability.

Dr. Chauncey Starr, North American Aviation, Inc., in his paper "City of Piqua, Ohio Project" reported that this system utilizing an organic fluid for both moderator and coolant was considered to be a very promising system for power production because of its simplicity of design and operation, and because it produced relatively high temperature heat in a low pressure system.

The principal problem associated with the use of organic coolants was the decomposition of the fluid under reactor radiation. Preliminary investigations have indicated that this problem can be satisfactorily met in actual operation. A major test of the stability of organics under reactor use is being performed in the operation of the Organic Moderated Reactor Experiment. This reactor, which began operation at the National Reactor Testing Station in Idaho on September 17, 1957, is designed to produce 16,000 kw of heat under engineering conditions very similar to those proposed for the Piqua plant.

This was followed by the paper "Consolidated Edison Indian Point Nuclear Power Plant" by **Gordon Milne** of Consolidated Edison Co. of New York. This unit will be a light water pressurized arrangement using highly enriched uranium 235 as the base fuel and thorium as the feed fuel. Since research on defective zirconium clad thorium metal fuel plates showed the corrosion products to have excessive volumetric increase, it was necessary to abandon the fuel element design which used alternate plates of uranium and thorium. Instead the fuel element will consist of the mixed oxides of uranium 235 and thorium enclosed in stainless steel tubes. The change from zirconium stainless steel cladding was made as one offset to the rapidly increasing first cost of the nuclear plant.

As a further attempt to offset rising costs, decision was reached not to enter the containment sphere while the reactor is operating. Thus, considerable radiation shielding inside the sphere is eliminated and the sphere reduced from 190 to 160 ft in diameter.

Major design items still to be settled are:

1—The relative amount of the excess reactivity to be controlled by the control rods and by boron poisons in the primary coolant and in the fuel.

2—The method of removing spent fuel elements from the reactor to the fuel handling building outside this

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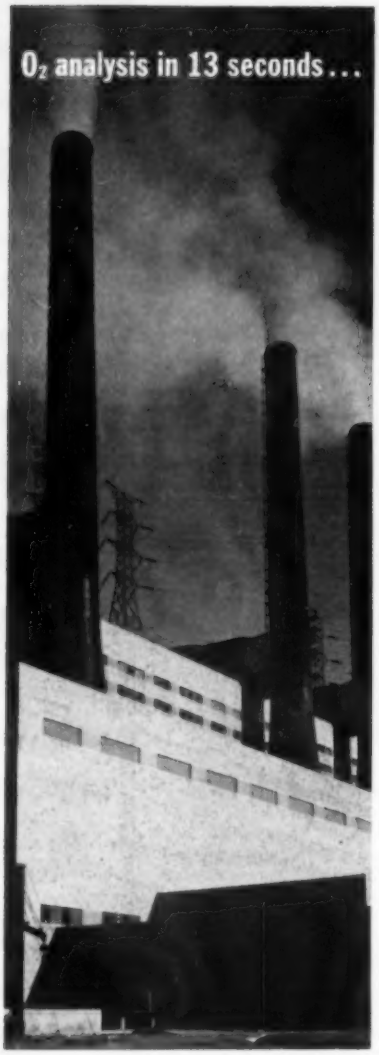

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sphere. A combined canal and inclined chute arrangement is under serious consideration.

3—The detail of the waste concentration and disposal system.

"Consumers Public Power District of Nebraska Project" was then described by **Dr. Chauncey Starr** of North American Aviation, Inc. The Sodium Graphite Reactor concept is an outgrowth of an early study program to determine the feasibility of producing the lowest cost plutonium through the simultaneous production of electrical power. This program, sponsored by the AEC between 1948 and 1953, was directed toward determining the then most promising type of dual-purpose plant. The study considered heavy water moderated reactors, gas-cooled concepts. The author's conclusions in 1952 were that the SGR and the PWR concepts were immediately feasible and that the SGR offered the greatest future performance possibilities. The growing interest in central station nuclear power plants brought forth a proposal for the Sodium Reactor Experiment and in 1954 this work was started for the Atomic Energy Commission by North American Aviation, Inc., through its Atomics International Division.

Sustained nuclear fission was achieved in the power reactor for the SRE on April 25, 1957, and electrical power was generated using reactor heat on July 12.

In 1955 the Atomic Energy Commission requested proposals for participation in the demonstration program for industrial power reactor development. The Consumers Public Power District submitted a proposal for such participation based on the Sodium Graphite Reactor designed by Atomics International, conceived as an extension of the Sodium Reactor Experiment which was at that time in the initial stages of development, engineering and construction.

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"Experimental Breeder Reactor No. 2" was then presented by **L. J. Koch,** Argonne National Laboratory. This unit, the EBR-II, is an unmoderated, sodium-cooled reactor with a thermal rating of 62.5 Mw and gross electrical capability of 20 Mw. It operates at a reactor sodium temperature of 900 F and generates steam at 850 F and 1250 psi. It employs "full size" sodium system components—pumps and piping systems of 5000 to 6500 gpm capacity—and utilizes a rather unique reactor and primary system design. The primary system—reactor, primary sodium pumps and piping, heat exchanger, and fuel handling system—is contained in a large tank, and all operate submerged in sodium.

The most significant feature of the EBR-II is the fuel cycle. The EBR-II will operate on recycled fuel, and the facility will include an integrated fuel process and fabrication plant. "Pyrometallurgical" processing will be employed consisting of fission product removal from molten irradiated fuel by volatilization and oxidative slagging. All of the fission products are not removed by this process, but those remaining—notably, ruthenium and molybdenum—appear to enhance the irradiation stability of the reconstituted fuel. Because their cross sections are not significant in a fast neutron spectrum, these fission products are permitted to build up to "equilibrium" concentration. Synthetic alloys (fissium) have been prepared employing "inert" fission product elements, and these have been tested for fabricability and irradiation stability. The alloy is quite brittle, but in the "as cast" condition it is very irradiation damage resistant.

The EBR-II fuel process requires the refabrication of highly radioactive fuel. The requirement of "remote control" fabrication has been an important consideration in the fuel element design, and has necessitated the development of simple fabrication and assembly techniques. These requirements have been met without violating the performance requirements for the fuel element as established by the reactor.

The subject of the "Homogeneous Reactor Experiment No. 2" was presented by **S. E. Beall,** Oak Ridge National Laboratory. As he reported construction and cleaning of the Homogeneous Reactor Test were completed and preoperational testing was begun in the summer of 1956. The testing was interrupted and critical operation of the reactor was delayed for about nine months by stress-corrosion cracking difficulties which were caused by chloride ion contamination in the stainless-steel leaak-detector system. During the past seven

months, the damaged flanges and tubing have been replaced and the preoperational testing with water and uranyl sulfate solutions has been completed. The reactor system is being tested for leaks, the containment tank is being sealed, and preparations are being made for the critical experiments.

During January, February, and March, the reactor was operated for a total of 1382 hours, including 665 hours with water at full temperature and pressure, as well as 520 hours at 1700 psig and 280 C with depleted uranium in the form of uranyl sulfate solution. During the final six weeks of the operating period, the reactor was "on the line" 80 per cent of the time. These runs accomplished the purpose of emphasizing weaknesses in equipment performance, as well as providing excellent training for the operating crew. For instance, it was clearly demonstrated that an improvement in feed pump performance was necessary, that the fuel-blanket pressure-control instrumentation was very satisfactory, and that the rupture-disk and relief-valve assemblies between the fuel and blanket system pressurizers were unnecessary. An acceptably low corrosion rate of less than 0.0005 in. penetration per year was established during the 520 hours of exposure to uranyl sulfate.

Robert T. Schomer, The Babcock & Wilcox Co., then discussed the "Liquid Metal Fuel Reactor Experiment (LMFRE) Status Report."

The LMFR concept referred to is interpreted to mean a liquid metal, circulating fuel, thermal breeder reactor. The fuel is a solution of uranium dissolved in bismuth; the moderator is unclad graphite, and the breeding fluid is a slurry of thorium-bismuthide dispersed in bismuth. Admittedly, there are other possible LMFR concepts, but it is B&W's opinion that this concept can be tested in the shortest period of time and has sufficient economic attractiveness to justify this effort.

The phrase "large-scale" is interpreted to mean a nuclear power plant producing a minimum of 200 Mw of electricity.

Even before the start of the design of the LMFRE, it was necessary to establish with regard to the LMFR concept, the major unknowns and questions of technical feasibility which must be explored and resolved. Having established these major unknowns and questions, a test program has been planned which will provide the answers to these questions; and an experimental reactor with necessary auxiliaries was then designed to fit this test program as well as possible.

C. W. Hasek, Jr., also of The Babcock & Wilcox Co., explained the "Nuclear Merchant Ship Propulsion Plant Status Report." This power plant is designed to develop 20,000 shafthorsepower at the normal rate of operation, and has a maximum rating of 22,000 shp.

The reactor system is of the pressurized water type and consists of a single reactor and two main coolant loops with two steam generators. The remainder of the plant includes a high pressure and low pressure turbine geared to a single propeller shaft, two turbogenerators, and an electrical distribution system serving all ship and plant auxiliaries, operational control systems, and associated auxiliary systems.

The reactor system, including the cooling system, the reactor, and the steam generators, and the pressurizer, intermediate cooling, purification, control and instrumentation systems are all contained in a pressure vessel approximately 50 ft long and 35 ft in diameter. This containment vessel is designed to contain the products of any rupture in the reactor system during operation. It is expected to go critical in January 1960.

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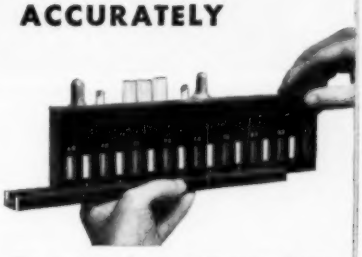

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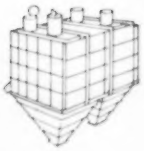

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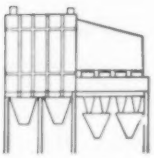

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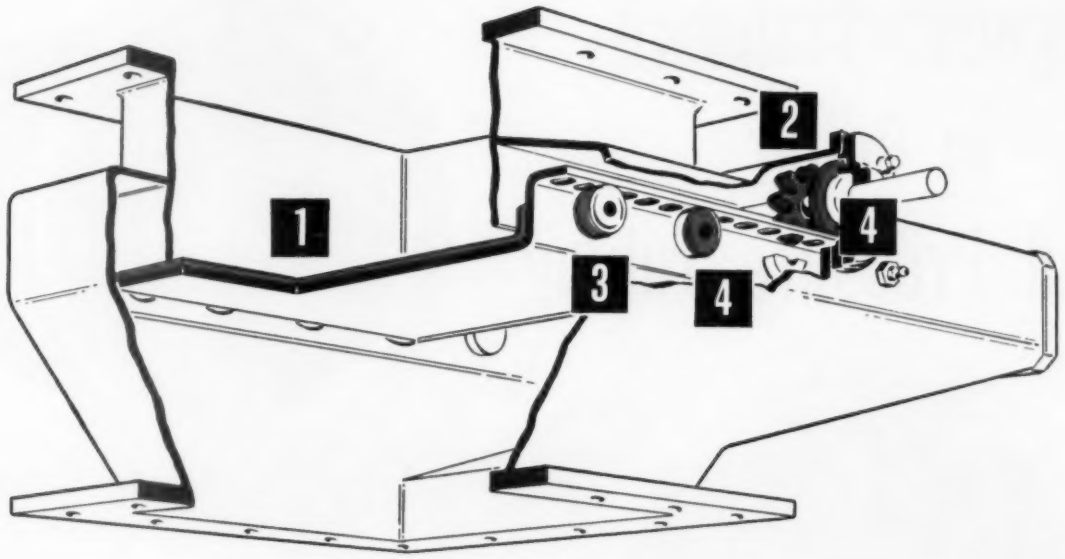

The inside story

ON THE S·E·CO COAL VALVE . . .

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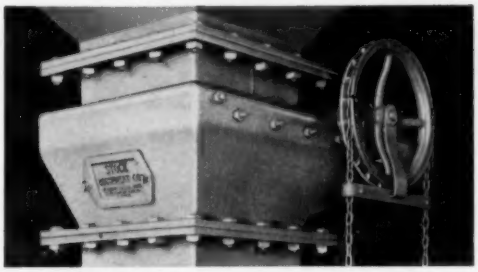

Wherever you find coal you find corrosion—or the possibility of corrosion. And wherever you find corrosion you find valves that stick, are hard to operate and that will soon need replacement.

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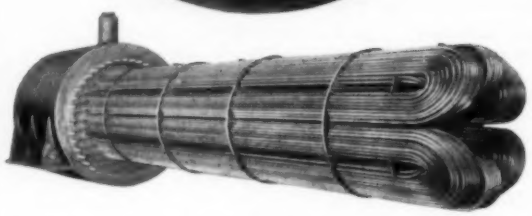

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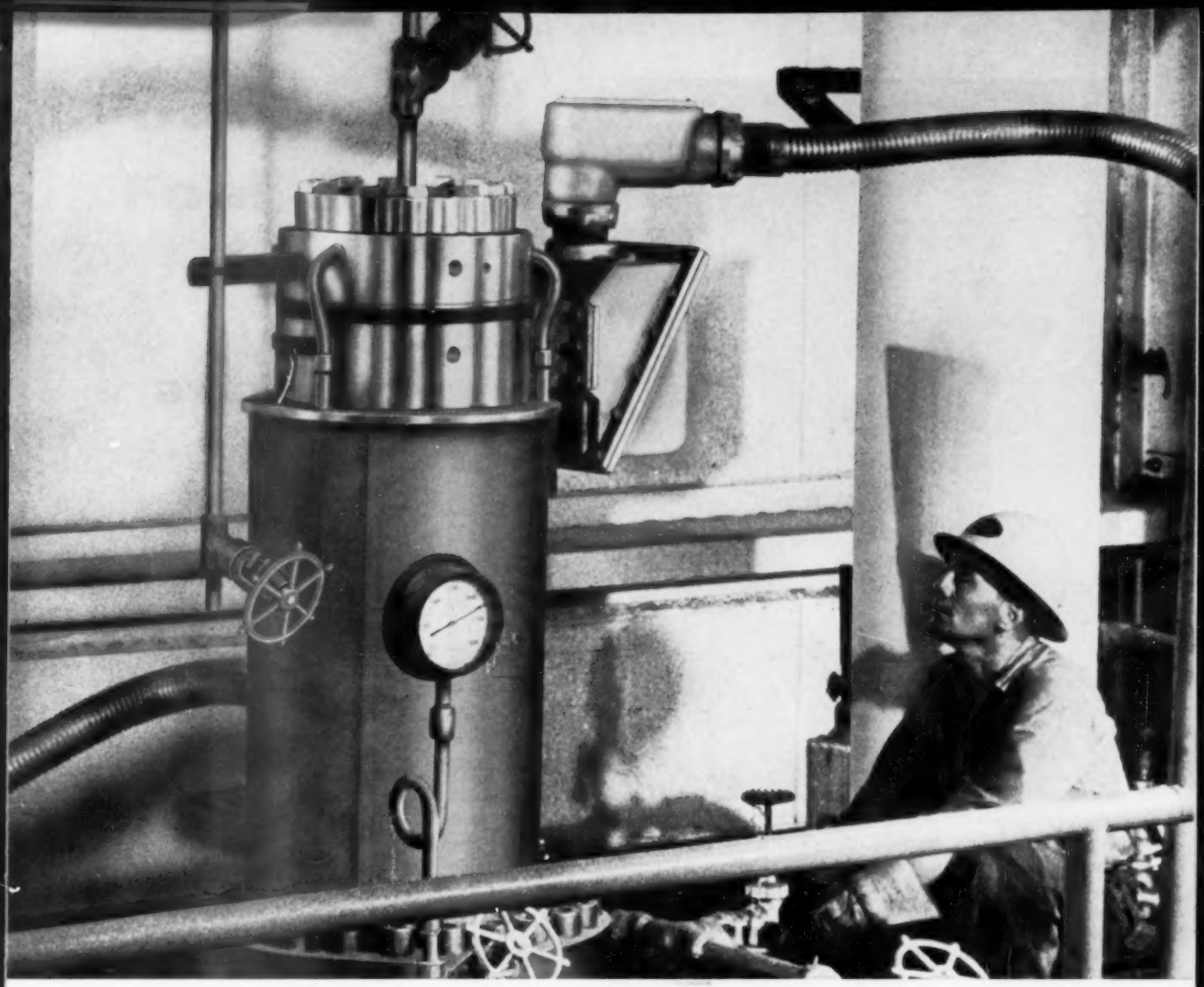

One of three "canned" motor-pumps on the controlled circulation boiler in the 125,000-kw addition to the Seward Station.

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THE important factors of . . . reliability, insured by the "canned" motor armature and field . . . zero leakage in high-pressure applications . . . and the excellent experience reported by other users . . . led to the selection of Westinghouse "canned" motor-pumps in this installation.

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For information on these pumps and the benefits which can be helpful to you, contact your Westinghouse sales engineer, or write to the Westinghouse Electric Corporation, Atomic Equipment Department, Cheswick, Pa. J-57017R

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M. W. Kellogg welcomes inquiries on its complete service to the power piping industry from consulting engineers, engineers of power generating companies, and manufacturers of boilers, turbines, and allied equipment.

Kellogg keeps pace in theory as well as practice. This 400-page book is the most comprehensive work ever made available publicly on the design of power piping. This volume, now in its 2nd Edition, is published by John Wiley & Sons, Inc., New York.

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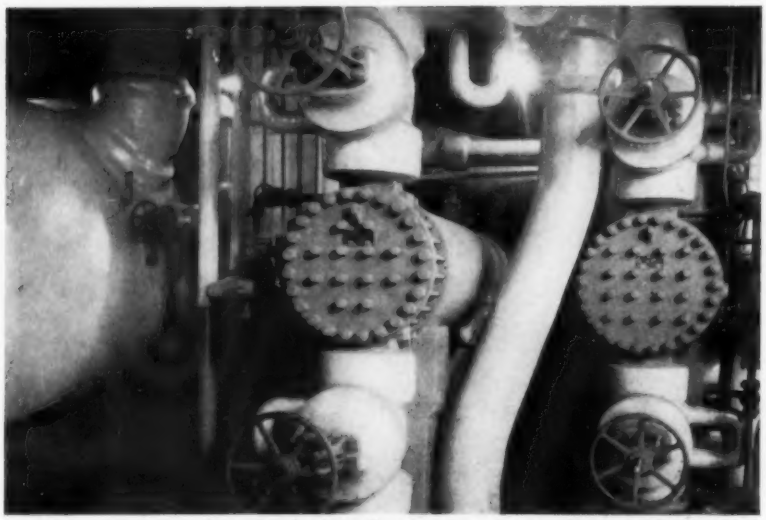

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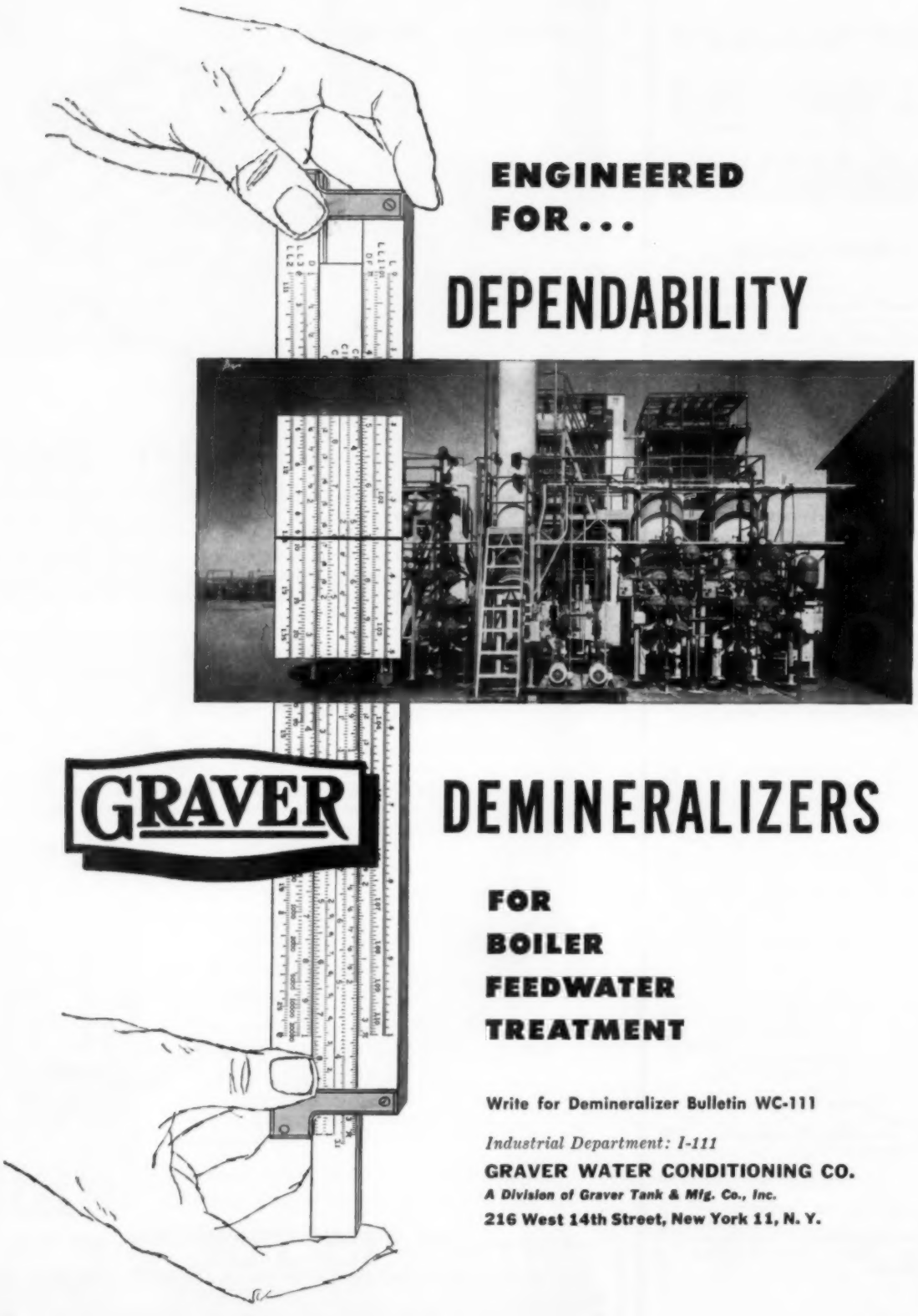

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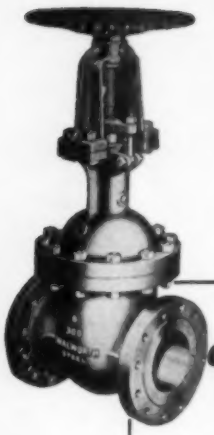
Cast Steel Gate Valves

Series 150 and 300

Wedge Gate — Outside Screw and Yoke



Sectional view of Series 300

Big 8-Point Superiority!

Gland clearances are such that stem cannot be scored if gland should be tightened unevenly.

Deep Stuffing Boxes in all sizes (2" to 24") insure tightness and maximum packing life – costly leaks are eliminated.

Bonnets and Bodies are engineered to withstand pressure and minimize distortion – they're tough, durable, dependable.

Heavy Steel Walls provide extra strength and longer life.

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Seat Rings are bottom seated – not flange type. No recess exists at back of ring – hence no turbulence, erosion, or pressure drop.

Streamlined Ports allow high velocity, non-turbulent flow, and reduce the possibility of erosion.

Valves regularly have flanged ends. They can be supplied with ends for butt welding. Roller bearing yokes are available. On valves 5 inches and larger, by-passes can be furnished.

For Series 600 and higher, we recommend Walworth Pressure-Seal Steel Gate Valves.

For further information on Walworth Cast Steel Gate Valves, see your local Walworth distributor, or write:

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valves and fittings

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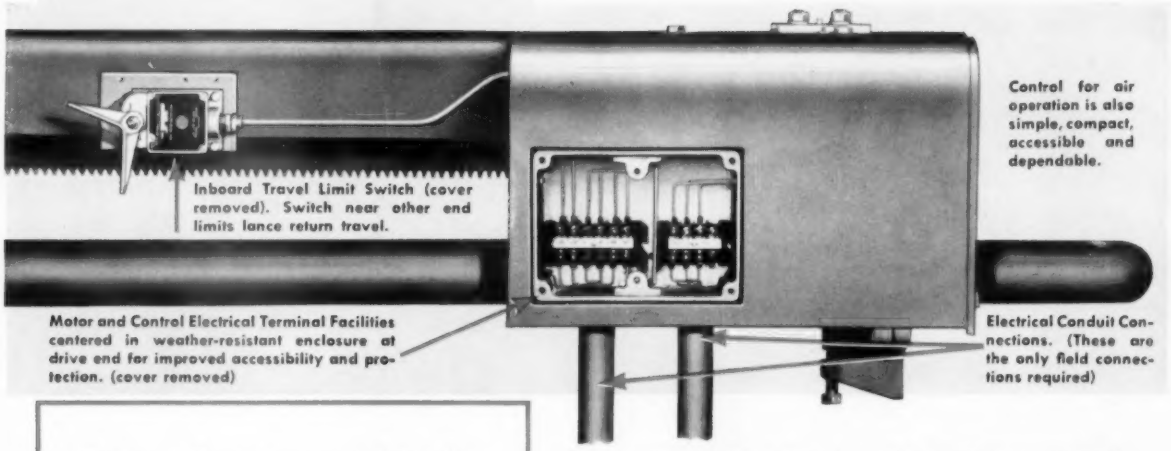
ELECTRIC POWER and CONTROL TERMINAL FACILITIES

ANOTHER IMPORTANT FEATURE of the new

Diamond series 300 IK

LONG RETRACTING BLOWER


Inboard Travel Limit Switch (cover removed). Switch near other end limits lance return travel.
Control for air operation is also simple, compact, accessible and dependable.
Motor and Control Electrical Terminal Facilities centered in weather-resistant enclosure at drive end for improved accessibility and protection. (cover removed)
Electrical Conduit Connections. (These are the only field connections required)

Other Advantages of Series 300 IK Blowers

- Backbone and Protective Cover
- Front End Single-Motor Drive
- Nozzle-Sweep-Every-Inch Cleaning Pattern
- Improved "Type A" Nozzle
- Positive Gear Carriage Drive
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- Positive Mechanically Operated Valve
- Single Point Outboard Suspension
- Oversize Lance (Step-Tapered for Extra Long Travel)
- Auxiliary Carriages for Extra Long Travel
- Designed for Quick, Easy Servicing

No other Blower gives you ALL THESE ADVANTAGES

Simple, convenient, rugged . . . the electric power and control center of the new Series 300 IK contributes substantially to the dependable, trouble-free operation of this blower. Terminal facilities and the control assembly are concentrated in a cast aluminum box at the drive end. No internal field wiring is required; the blower is completely wired at the factory. The control is linked directly to lance travel and is governed by two durable snap switches . . . actuated by a cam on the lance carriage.

Additional important features of the new Series 300 IK are listed in the panel at left. Check them and you will understand why this blower is establishing a new standard of efficiency, economy and dependability in cleaning those heating surfaces that require a long retracting blower. For further information about the new Series 300 IK, ask the nearest Diamond office or write directly to Lancaster for Bulletin 2111V.

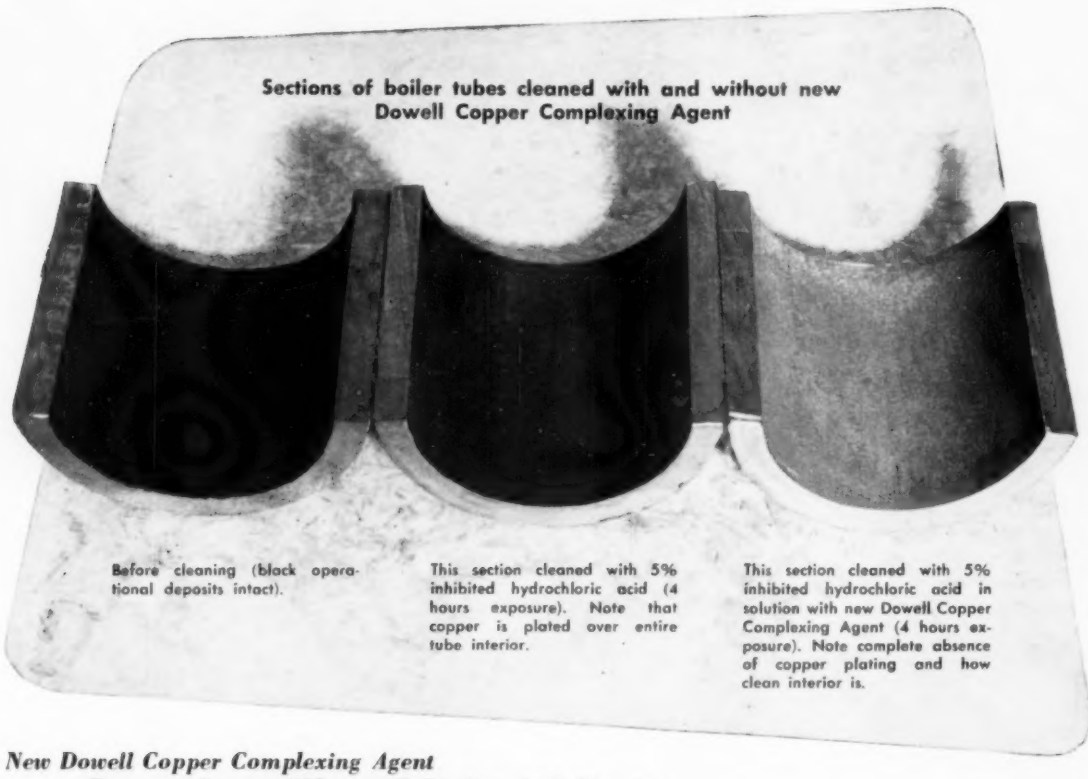
New Series 300 IK
Long Retracting Blower.

7952

Diamond

DIAMOND POWER SPECIALTY CORP.
LANCASTER, OHIO
Diamond Specialty Limited • Windsor, Ontario

New single-stage chemical cleaning service removes copper, water-formed scale from boilers


Sections of boiler tubes cleaned with and without new Dowell Copper Complexing Agent
Before cleaning (black operational deposits intact).
This section cleaned with 5% inhibited hydrochloric acid (4 hours exposure). Note that copper is plated over entire tube interior.
This section cleaned with 5% inhibited hydrochloric acid in solution with new Dowell Copper Complexing Agent (4 hours exposure). Note complete absence of copper plating and how clean interior is.

New Dowell Copper Complexing Agent Prevents Copper "Plate-out" During Acid Cleaning

Dowell research has solved the problem of removing copper deposits, along with iron oxides and other water-formed deposits, in a *single-stage*, acid-fill boiler cleaning job. This single-stage chemical cleaning is made possible by a new copper-complexing agent*. When added to Dowell's regular cleaning solvents, this agent acts to dissolve copper deposits, and to complex copper ions so that they remain in solution in the spent acid and do not plate out on the newly cleaned metal.

Removal of copper from boiler tubes is of prime importance. Galvanic cells may be formed between the copper particles and exposed steel surfaces. Such cells may contribute to pitting during normal operation of the unit. Also copper deposits may interfere with heat transfer, leading to localized over-heating and sudden failure of the boiler tubes by rupture. Freshly plated copper may even slough and cause stoppage of the tubes.

Another distinct advantage of this new single-stage boiler cleaning service is in reduced boiler outage time. Boiler tubes can now be chemically cleaned—removing copper deposits in addition to water-formed scale and sludge in about one-half the time previously required to perform this service.

For complete information on how this new copper-complexing agent can help you, call the Dowell office near you. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

*PATENT PENDING

have Dowell clean it chemically

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